Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

APRIL 1949

AMBERLITE W-1—a water-soluble polymer for improving the dry and wet tensile and Mullen, as well as the fold, and the abrasion resistance of paper.

RHOZYMES BB and E-5—for enzyme conversion of starch.

TAMOL P—for effective pitch control—a dispersing agent for pigments.

TRITONS—surface-active agents with a score of uses in paper manufacture—in caustic cooking of cotton fiber, as a dispersing agent for pigments and metallic soaps, emulsion-type coatings.

The Hydrosulfites—reducing agents for stripping color from rag stock or for bleaching pulp.

HYAMINES—deodorants for paperboard and glue bactericides.

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"If it isn't wet-strength paper I don't want it!" Before customers begin saying that to you, safeguard your market—wet-strengthen your paper with the UFORMITES.

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The Resinous Products Division was formerly The Resinous Products & Chemical Company

Marathon: waxing and carton

At Menominee, Michigan, the recently acquired mill of the Marathon Corporation, shown above, is responsible for a considerable volume of this old-line company's high-quality waxing papers. A new Beloit Yankee Fourdrinier contributes to the mill's production. Four Beloit machines are in Marathon's mill at Rothschild, Wisconsin, and two at Ashland, Wisconsin, installed more than 30 years ago. There are also two at Menasha, Wisconsin, built more than 50 years ago. All have since been rebuilt with Beloit equipment and are still producing efficiently.—*Beloit Iron Works, Beloit, Wisconsin.*

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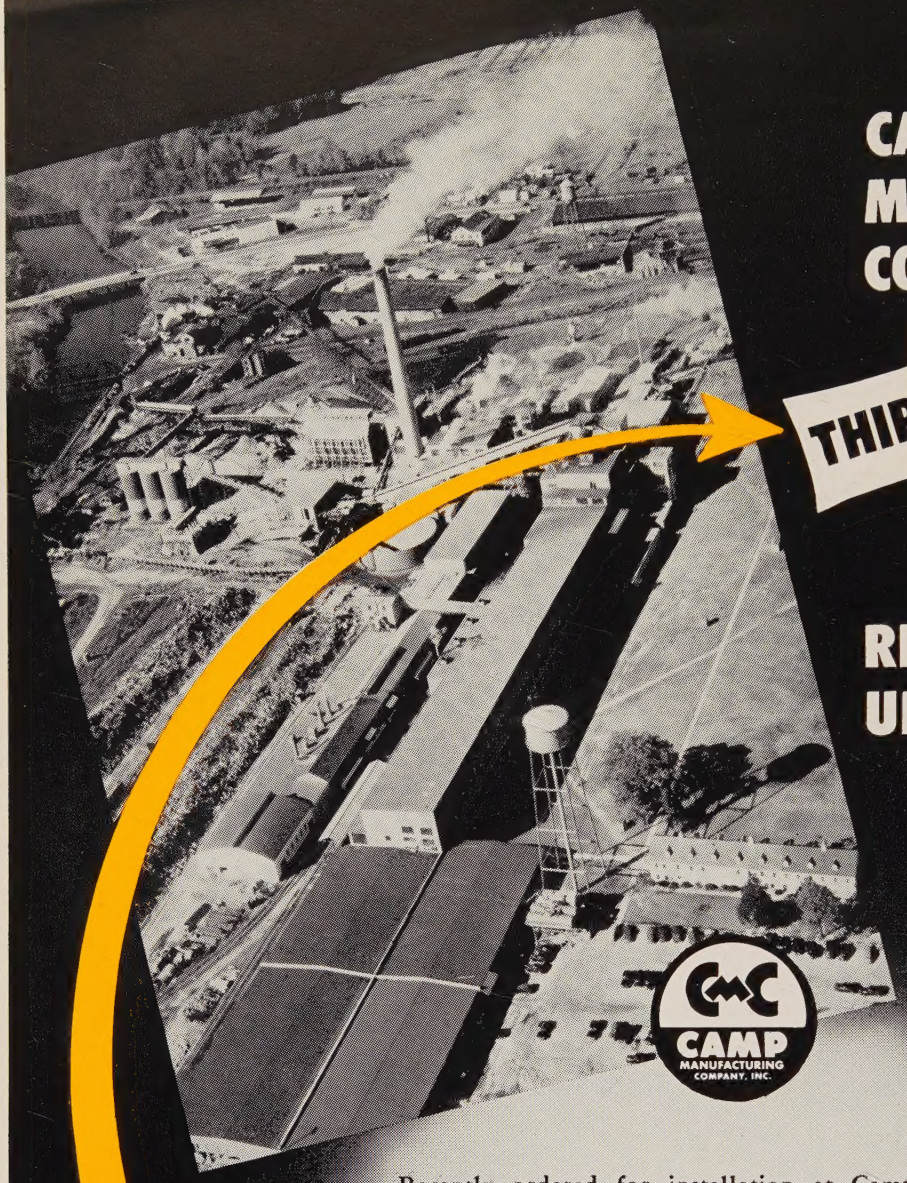

CAMP MANUFACTURING COMPANY ADDS THIRD B&W RECOVERY UNIT

CMC CAMP MANUFACTURING COMPANY, INC.

Recently ordered for installation at Camp Manufacturing Company's Franklin, Virginia sulphate pulp mill is a 350-ton B&W Recovery Unit.

Satisfactory service from the B&W Organization and B&W Products over a period of years influenced the selection of the new unit. Service-proved since the war, today's B&W recovery unit represents the last word in efficient chemical recovery, and reduction, high steam capacity, maintenance simplicity and operating reliability.

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P-33

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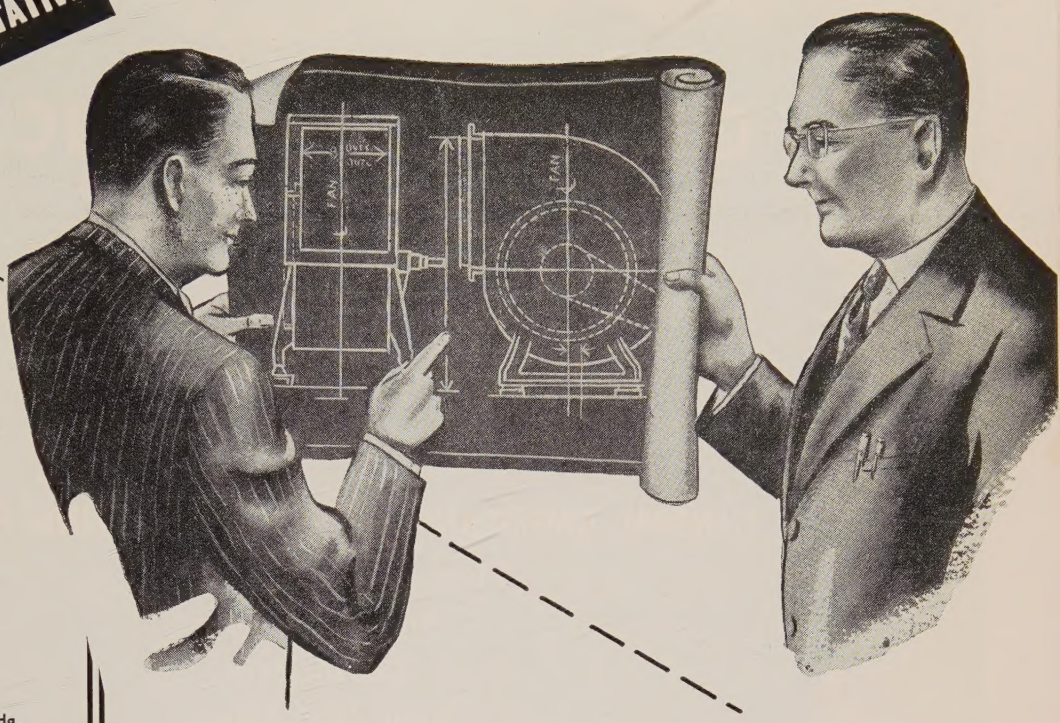

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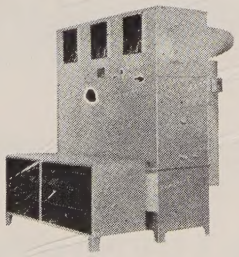
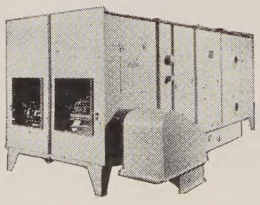
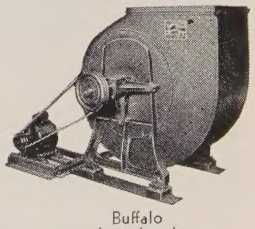
"Buffalo" representatives know their equipment and the jobs it is designed to handle. They are Graduate Engineers with one to five years of factory training, in addition to wide field experience. And they have all the resources of the "Buffalo" home plant engineering staff to back them up.



Buffalo Air Conditioning Cabinet



Buffalo Air Washer



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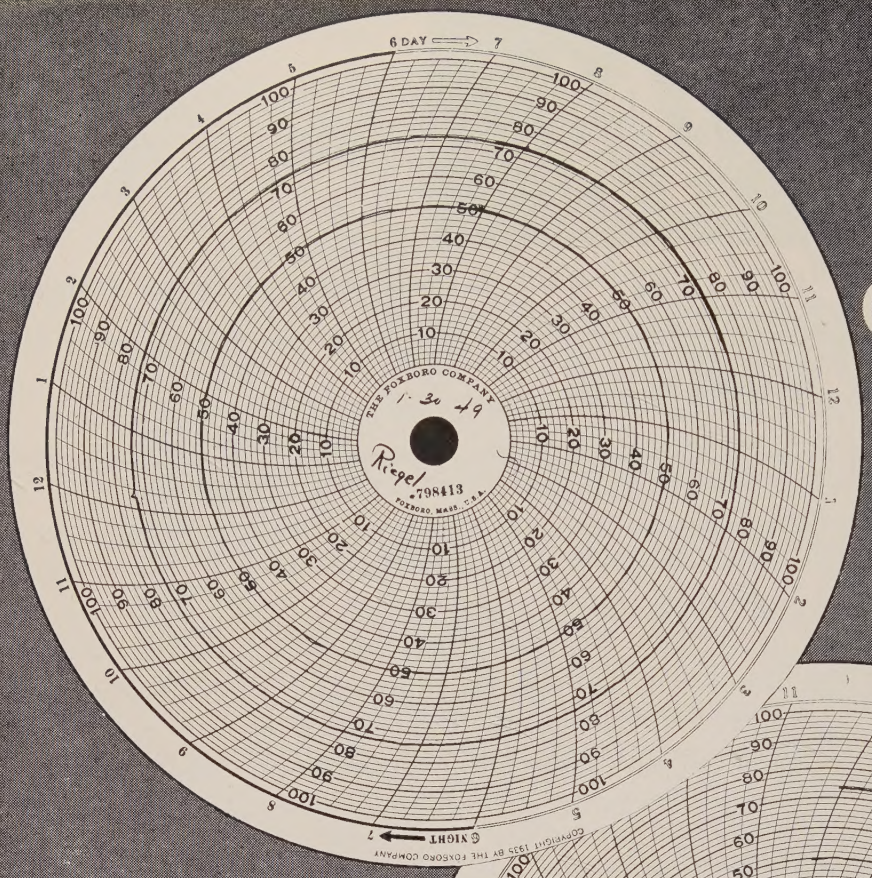
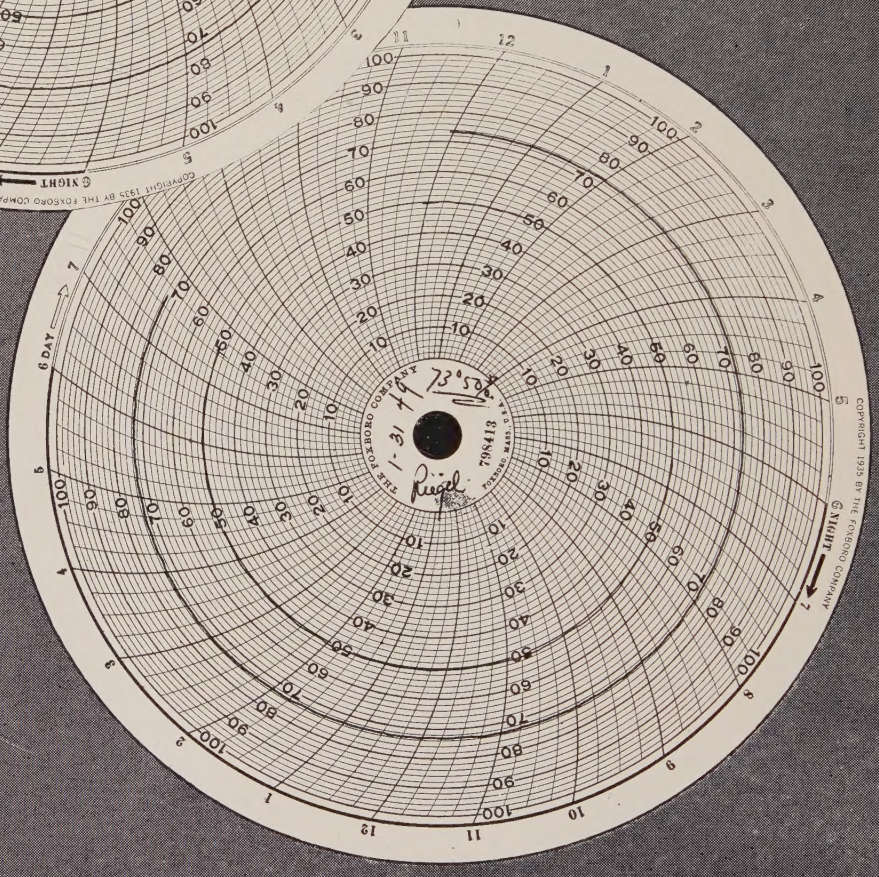
ROSS AIR CONDITIONING





ACTUAL CHARTS OF CONSTANT TEMPERATURE AND HUMIDITY ROOMS AT RECENT INSTALLATION OF RIEGEL PAPER CORPORATION, MILFORD, N. J.

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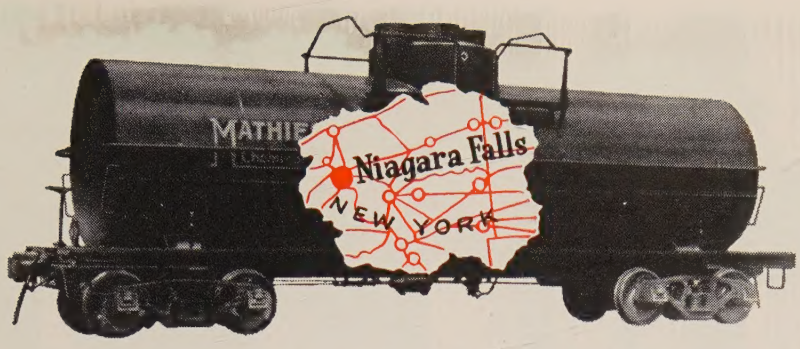

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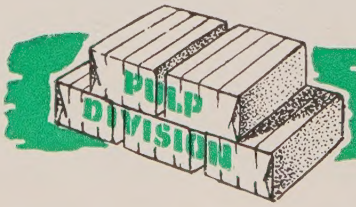
THIS IS PRE-LOGGING

Pre-logging is the harvesting in advance of smaller trees which otherwise would be damaged or destroyed if left until the big trees are logged. This isn't as simple as it sounds. To pre-log efficiently meant devising special new and mobile logging equipment.

However, the effort is justified in the recovery of many cords per acre of good clean material, highly desirable in the manufacture of sulphite or sulphate pulp.

Pre-logging fits into the method of "block" harvesting as used in the Douglas fir region, where forest lands are clearcut in a patchwork pattern, leaving blocks of seed trees as a source of regeneration. This is all part of the cycle of growth, harvest and regrowth known as Tree Farming.

Weyerhaeuser's use of the pre-logging method is another step toward more complete utilization of the timber crop.



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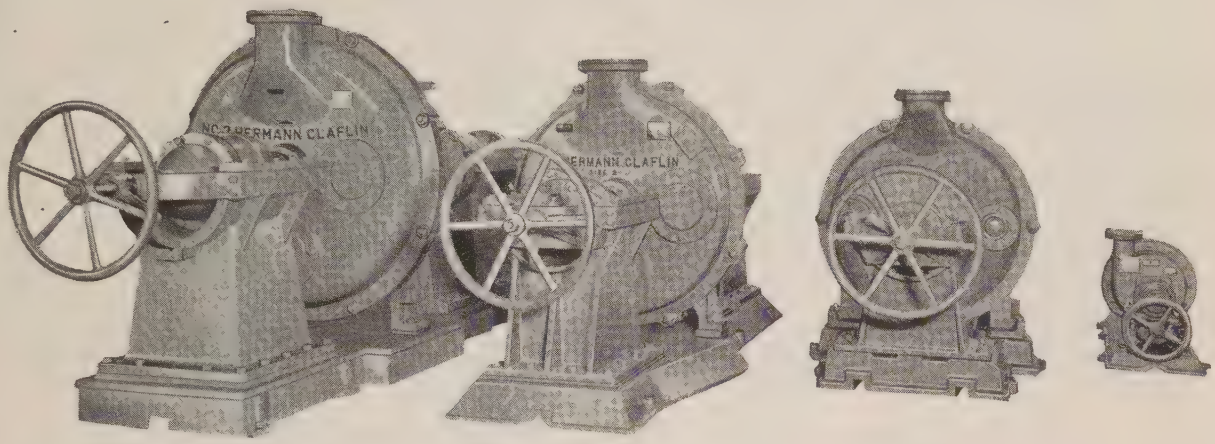

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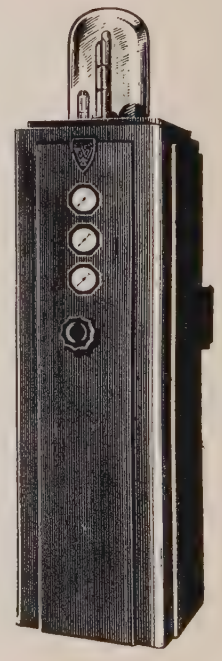

Write today to learn how these advantages of Break-Point Chlorination—backed by Wallace & Tiernan's 35 years' experience in water purification—can go to work for your mill.

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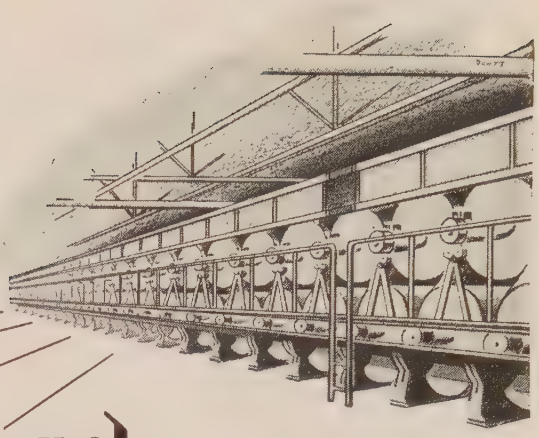
PP9-1

A simple chemical equation but a manufacturing headache...



$$2Cl_2 + 3Ca(OH)_2 = Ca(OCl)_2 + CaCl_2 + Ca(OH)_2 + 2H_2O$$

In the text book, the reaction between milk of lime and chlorine to make liquid bleach is simple enough. Just add chlorine to milk of lime and you've got liquid bleach. But how to do this safely, economically and uniformly, occupied the time and efforts of chlorine producers for a good many years after World War I.

Hooker paper technicians, chemists and engineers, contributed their services to this all-important project. They showed pulp and paper makers how to handle chlorine safely, how to get it into the milk of lime for more efficient production of high quality liquid bleach. The principle of the cone injector, widely used in pump circulation systems, was applied by Hooker engineers and proved an efficient method for securing more thorough mixing of chlorine and milk of lime.

Hooker's cooperation with pulp and paper makers is on a continuing basis. It is evidenced in research and the development of production and process techniques. It is continued by providing you with uniform high quality liquid chlorine, caustic soda and the other pulp and paper chemicals. Hooker helps you to turn out quality products economically and uninterruptedly.

Hooker bulletins for the Pulp and Paper making industry contain helpful information. Send for a list of those available.

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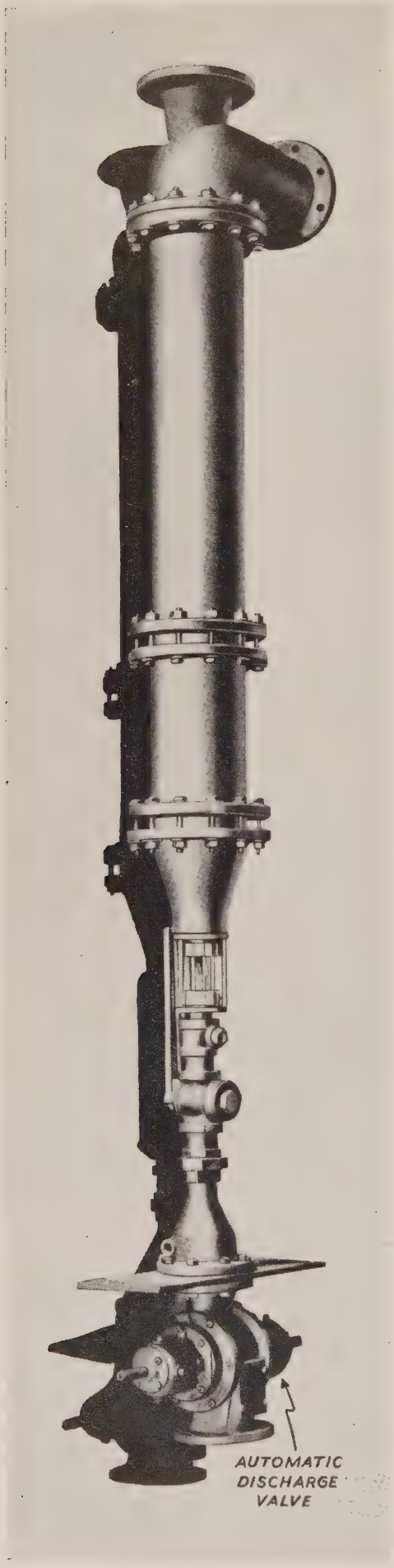

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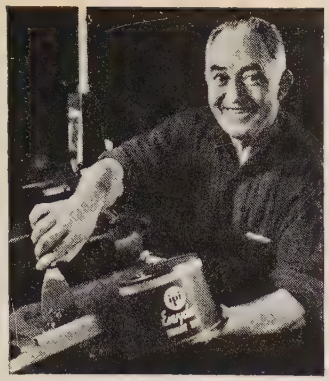
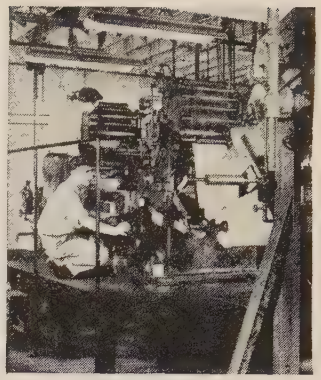
Got a beauty to print? Try our Holdfast* Halftone Blacks. They print clean, sharp; dry in 4 to 6 hours, faster with heat; available in non-scratch formulations, too.

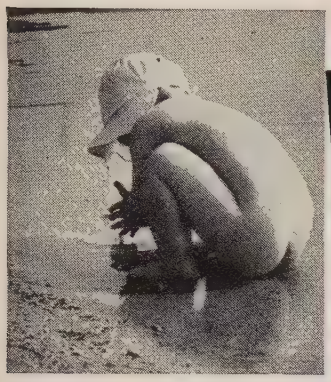


Our Everyday* line of packaged inks enables printers to reduce ink inventory, yet be prepared to do beautiful color . . . and black-and-white . . . printing of all kinds.

Our Gemtone* Process Colors for sheet-fed presses look as bright when dry as they do when wet. You get sparkling results because they dry on top of the sheet . . . fast!



More than 200 publications use our Vaporin* heat-set inks for web presses. Other Vaporin formulations, for sheet-fed presses, dry rapidly with only gas bar heat.



Our Vaposet* inks set in moisture. Ideal for packaging, they are odor-free, have excellent waxing and heat-sealing qualities, and set instantly on moist corrugated board.

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*Trade-mark of Interchemical Corp.

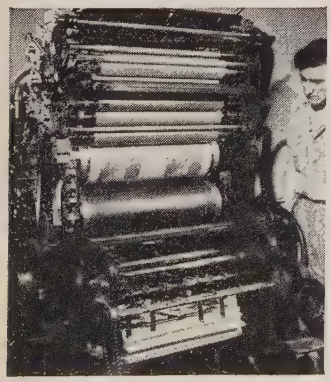
We have a complete line of inks for fibre board containers. Our Vaposet inks set instantly on moist, corrugated board, eliminate waiting for either board or inks to dry.

IPI* is a leader in inks for package printing—letterpress and offset—for paper bags, cotton bags, folding boxes, transparent materials, metals, plastics, foils and glass.

Our Anilox* inks for aniline printing provide opacity where it's needed on transparent package materials. They're 100 per cent pigmented and highly lightfast.

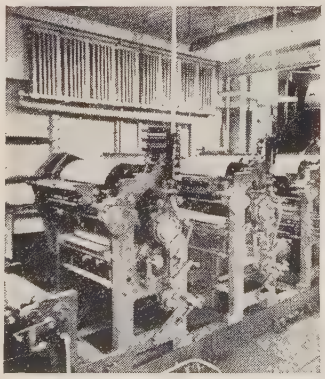
IPI has years of experience in news-color printing—offers R.O.P. colors, halftone colors, process colors, and "know how." News blacks? Of course, for every type of press.

We make a complete line of metal decorating inks, including our Elixirin* inks for quality wet-ink varnishing...which also give excellent results when dry varnished.



Greasing, scumming, emulsification, and bleeding are reduced with our Press-tested* offset inks. They're tested on presses which lithographers, themselves, use.

Our Tri-Metal* offset plate permits press runs of a half-million impressions or more with remarkable uniformity. The last impression is as clean and sharp as the first.



Our Vapolith* inks for web offset presses set instantly with heat. Vapolith inks for sheet-fed presses dry without heat in one to five hours, produce brilliant color.

IPI is practically a "department store for litho supplies." We have plates, blankets, Aquatex, Dampabase, and anything else you may need—including quick service.

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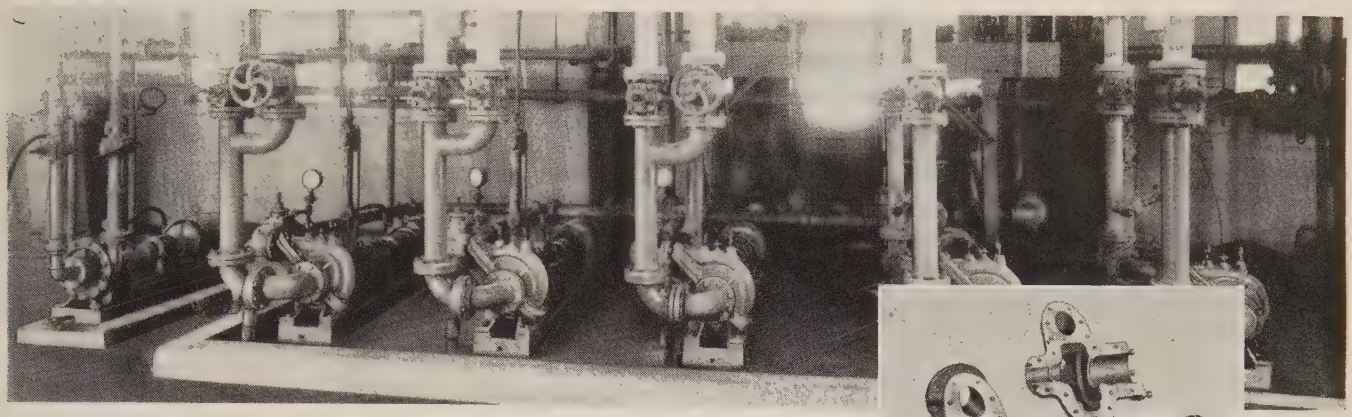
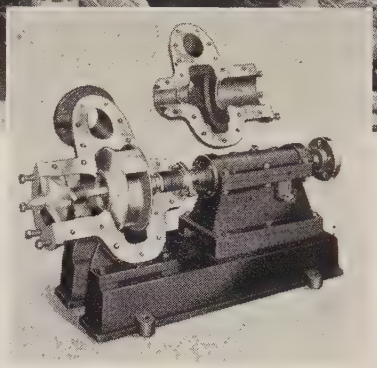
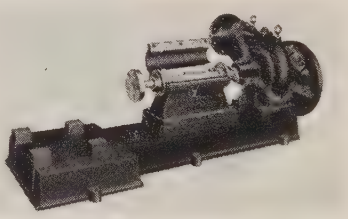




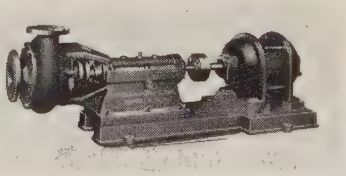
Buffalo Diagonally Split-Shell Pump for high consistency stock

"Buffalo" PAPER STOCK PUMPS

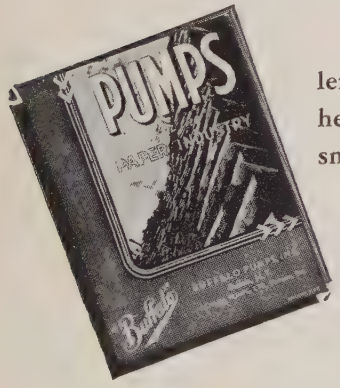
When you buy a pump, you want smooth, reliable economical performance for YOUR PARTICULAR PROCESS CONDITION. That is why it pays to look into the COMPLETE "Buffalo" line. For "lumpy" liquids, for acids, for slurry, for "high-head" jobs or any condition to be found in the paper mill, there's a "right" pump for the job. All "Buffalo" Pumps are oversize for extra endurance—non-clogging for simple maintenance —efficient for power savings.



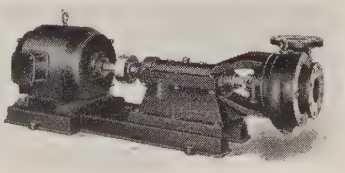
Buffalo Rubber-lined Stock Pump



Buffalo Solid Shell Pump for circulating and agitating



WRITE FOR BULLETIN 953-F, at left—pick the "Buffalo" Pump that will help keep YOUR process going smoothly!



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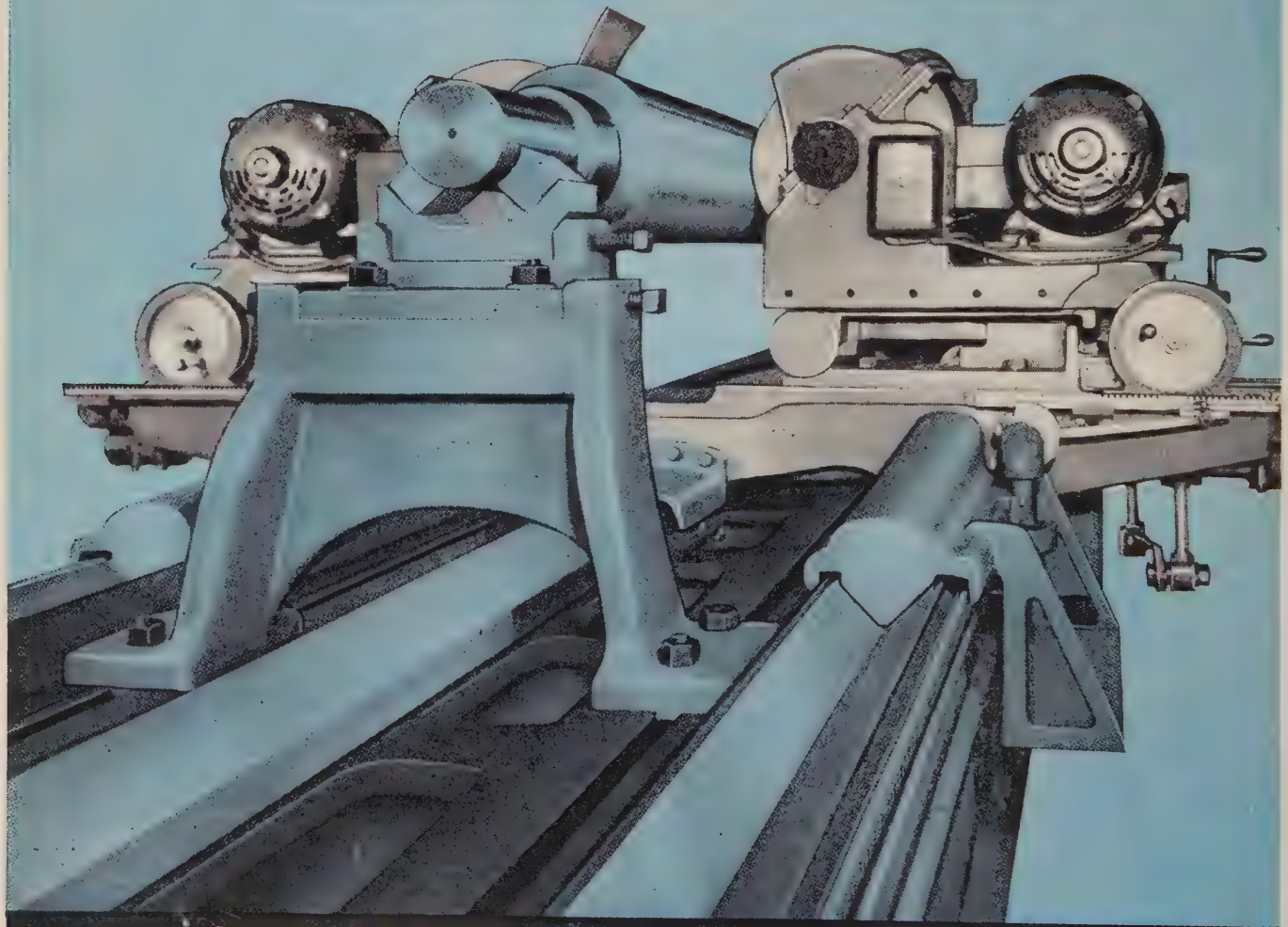

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With great pleasure we announce the formation of the Rice Barton Research Corporation, a wholly owned subsidiary of Rice Barton Corporation.

The purpose of this new organization is to conduct process and product research for the paper industry. Its further purpose is the sale and promotion of equipment which will be developed with its own resources and with the help of its many friends in the industry.

The initial step in this direction is a connection with Mr. Kurt Wandel, whereby the Rice Barton Research Corporation will further develop and sell machines basically designed by Mr. Wandel and known to the industry as "DynoMachines."

These machines - DynoPulpers, DynoFiners and DynoChests are operating most successfully in a number of mills throughout the country. Rice Barton Research Corporation is proud to have the exclusive sale and further development of this line of equipment.

In continuing advertisements we plan to bring to your attention the many advantages and achievements of these DynoMachines. We welcome your inquiries.

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President

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Product and Process Research
For the Paper Industry

The PRESIDENT'S PAGE

Albert E. Bachmann

The Next Few Steps

As a preview to outlining some of the next phases of the continuous advance in progress of the Technical Association it might be well to consider briefly some of its recent achievements.

Over the years, each succeeding group of officers and executive committees, in addition to consolidating previous advances, have attempted to concentrate on a relatively few new objectives and their contributions have been largely reflections of their own particular interests and of the needs of the times.

During the long wartime period, which created its own demands, the Association devoted its energies largely to the development of a wide variety of wartime standards as well as the development through coordinated research of badly needed wartime containers and packaging materials.

Since the war the Association has devoted much effort to an intensified study of certain committee programs. Under the leadership of President Gunnar W. E. Nicholson and his indefatigable Engineering Division Chairman, J. W. Hemphill, particular stress was given to the needs of the industry's engineers. The expansion and rehabilitation of the industry in a period of shortages and rising costs called for coordinated effort and a means whereby power, construction, and maintenance engineers could get together to discuss problems of common interest. The successful launching of the annual engineering conferences and the attendant large increase in our membership among the industry's engineers have proved the constructiveness of this innovation.

The pent-up advances in knowledge of cellulose chemistry, groundwood, testing methods, alkaline pulping, straw pulping, plastics, and other fields, were released in specialized topical meetings under the able leadership of President Gillespie and such chairmen as Harry F. Lewis, John L. Parsons, J. d'A. Clark, K. G. Chesley, S. I. Aronovsky, E. C. Jahn, and several others. The conferences arranged by these members have greatly enriched the industry's literature and brought us all up to date on recent developments.

Under the leadership of President Gillespie also, inspired to an extremely large degree by George J. Brabender, the Association advisedly brought forth one of its most significant developments, to date, in the form of its new magazine, *Tappi*. A representative publication management board and a strong functional editorial board have been organized to develop details of policy for executive committee approval in connection with the operation of the new publication. This new publication *Tappi* will undoubtedly unfold new possibilities for information exchange as we increasingly learn to use it and realize all its inherent possibilities. It will require clear thinking and everlasting effort to bring out the full quality and usefulness of the publication but with the leadership of such men as Dr. C. J. West and his Editorial Board much of value can be confidently expected.

The divisions and committees covering engineering, testing, pulp and paper manufacturing, paper converting, research activities, etc., are all headed by unusually capable chairmen. They are busy men who are willing to give some of their time to the industry's technical advancement. Their efforts are being devoted to a constant appraisal of the industry's needs and their accomplishments are reflected in the many conferences sponsored by the Association and the publications that are evidence of these meetings.

Our local sections are of importance to the Association. They bring the Association closer to its members. Under the coordinative direction of the late President W. E. Brawn and K. P. Geohegan, as Chairman of the Executive Committee's Subcommittee on Local Sections, and the able leadership of many of our younger members the local sections have become more closely associated in aims with national TAPPI. Executive Committee coordination of local sections has recently been vested in H. W. Bialkowsky. He expects to work closely with the local section officers to assist them with their programs in various ways and to investigate the possibilities of local section sponsorship of committee projects.

Our Association is composed of three elements—the Committees, the Sections, and the Individuals. The Committees with a few exceptions are functioning admirably, the Sections are well organized under capable leadership and are all producing regular programs of real merit and interest. On the level of individual participation in the activities of TAPPI, there is an opportunity for some improvement. One of the major problems which looms before us is how we can best excite the interest for more active participation in our activities of a greater proportion of our membership.

(*continued on page 22 A*)

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The Starch Stabilizer

Stops Gelling
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Sample on request

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THE PRESIDENT'S PAGE

(*continued from page 20 A*)

For one thing, we expect that our new publication will provide a rallying point about which the Association's far-flung activities can revolve. Some innovations may take the form of publishing our manufacturing methods inquiries and answers, also critical reviews or data supplementary to already published articles. A "Letters to the Editor" section may give our members a means of getting ideas over short of formal papers.

An important committee, which, by its very diversification, can provide many opportunities for greater participation by individuals, is the Paper Manufacturing Committee. This committee is capable of being expanded into a very large number of subcommittees to thereby afford an opportunity for collaboration of people having common interests. We hope that the response to the reorganization of the Paper Manufacturing Committee will justify our becoming able, in the near future, to schedule a topical type fall meeting devoted entirely to various phases of paper manufacturing.

One of the important results of TAPPI activity in the past has been to encourage standardization with respect to testing methods and calculation and recording of results in appropriate units. Considerable need exists in the standardization of testing methods, in actual use by the mills, for controlling process operations. The Association will shortly issue in loose-leaf form the routine control methods which have been gathered by generous contribution from many mills, during the past two years. These methods after issuance will, under the guidance of our testing committees, undergo a process of refinement which will undoubtedly produce a greater degree of standardization which will be extremely valuable.

A need also exists for the establishment of standard methods of measurement and calculation for operating and efficiency ratios and yields of various kinds, which are presently used rather loosely for comparative purposes between mills. Many such ratios, expressed in terms of production units or coupled with time units, can form the basis for the many standards required for an eventual standard cost system. This requires considerable work of an engineering, technological, or analytical nature and is best performed by collaboration of technical, cost, and operating men. There exists a distinct need for a sort of stoichiometry of paper technology.

An important opportunity for the future consideration of some of our specialists lies in the assembly of the essential parts of our sprawling literature into connected wholes by related subject matter. The need for such extensive reviews or collations is apparent to many of our members who may suddenly desire to get abreast of new fields which have suddenly assumed importance to them. They are likewise important to our younger members and those whose work has been changed and who consequently do not know how much of the older material has been superseded by the latest technological advances. Such reviews will also tend to bring to light important specific gaps in our connected train of knowledge of a subject and will accordingly, tend to stimulate research on such matters.

Such a program has already been started through our monograph system and the book on bleaching on which the Pulp Purification Committee is currently working. A long-term project of a similar nature, to which all committees and individuals could contribute their mite is the expansion of the existing system of TAPPI Data Sheets. This could well, at some future time, develop into an engineering handbook of paper technology similar to the engineering and chemical handbooks which grew from very small beginnings.

Your executive committee will work diligently to bring about the consolidation of our existing developments and the promotion of further advances by attempting to provide the proper organizational structure and initial impetus. The eventual leadership and follow-through necessary for successful accomplishment in so many diverse activities must, of necessity, come from each of us searching for the niche in which our experience, training, and talents permit us to participate fully. If the proper environment for response, in the form of proper organization, is created and each of us searches diligently for the spots in which he can give of his experience and factual knowledge, it will no longer be necessary for us to painfully assemble fragments of knowledge like picture-puzzle pieces in attempting to come to a complete understanding of even some of the more commonplace phenomena associated with our daily work.

One of the Men Behind EASTWOOD WIRES—

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Thousands of feet of shute wire are uniformly wound on the bobbin which John Race holds in his hands. These bobbins ride the shuttles that speed back and forth across our looms.

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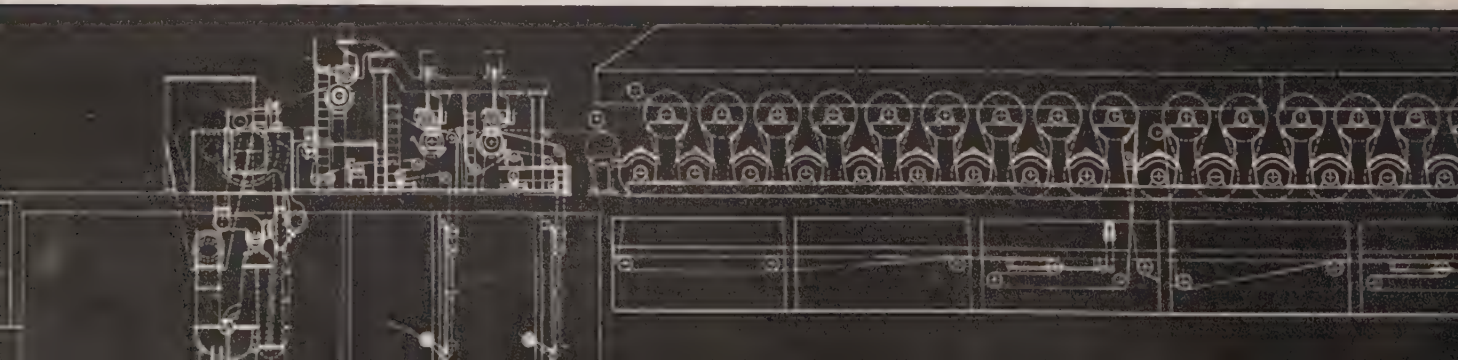
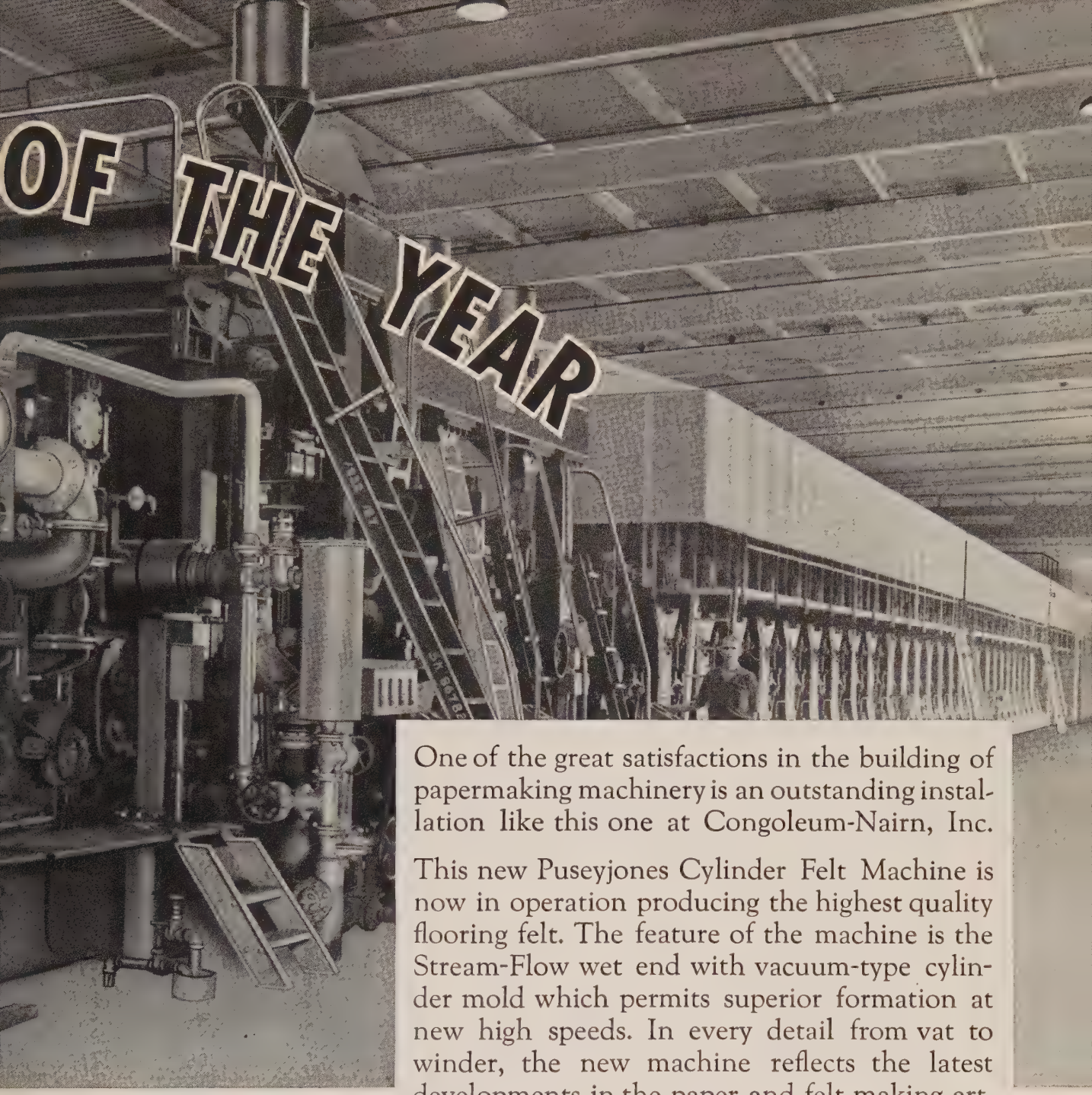
168" Puseyjones Single Cylinder High Speed Felt Machine in Cedarhurst, Maryland, mill of Congoleum-Nairn, Inc. Designed and built for the manufacture of highest quality Flooring Felt.

Line drawing of new machine. Features include latest type Stream-Flow Vat System with Vacuum Cylinder Mold, Flow Spreader and Up-Flow Head Box; Press Part of pneumatically operated Simplex design, including suction primary press, main plain first press and forward suction second press; Dry Part arranged in four drive sections with sixty-seven 60" diameter dryers mounted in anti-friction bearings, with enclosed gearing, and rope carrier system for threading the sheet; latest type Steam Joints with dual revolving siphons; One 3-roll Calender Stack with heavy duty anti-friction bearings; Pope-Type Reel; Unwinder with pneumatically operated brake; 2-Drum Winder with hydraulic unloading table; all rotating parts dynamically balanced for top driving speeds. Multiple-generator type sectional electric drive.





One of the great satisfactions in the building of papermaking machinery is an outstanding installation like this one at Congoleum-Nairn, Inc.

This new Puseyjones Cylinder Felt Machine is now in operation producing the highest quality flooring felt. The feature of the machine is the Stream-Flow wet end with vacuum-type cylinder mold which permits superior formation at new high speeds. In every detail from vat to winder, the new machine reflects the latest developments in the paper and felt making art.

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Established 1848. Builders of Paper-Making Machinery
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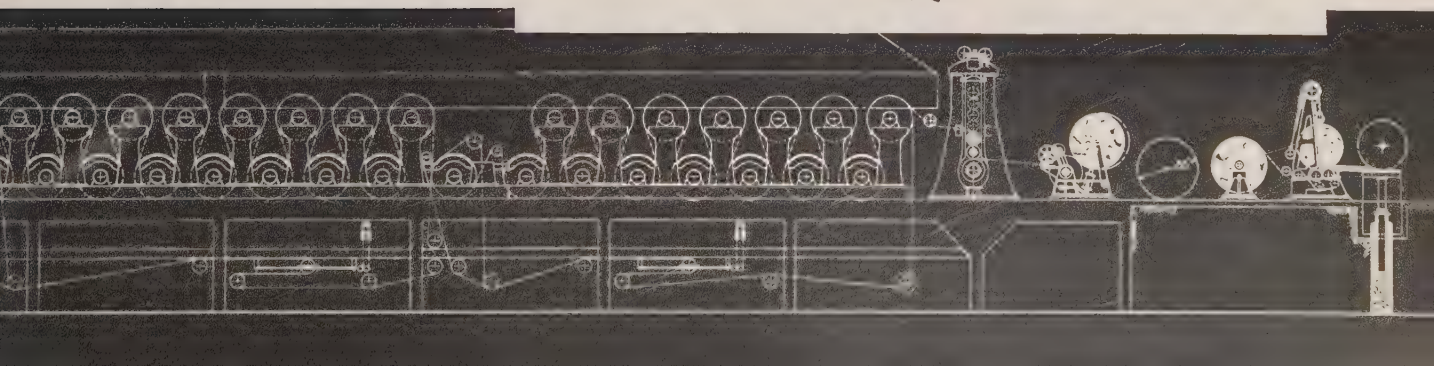


EDITORIAL *Tappi* COMMENT

The Coating Conference

For so many years the national meetings of the Technical Association have been held in February and in the fall that it is a little difficult to refer to The Coating Conference at Grand Rapids, Mich., on April 26–27 by any term other than as a fall meeting. Last year our two meetings in August were called fall meetings. Perhaps the fall is coming early this year due to a mutation of the seasons caused by the atomic bomb at "Bikini." Elsewhere in this issue is a listing of the papers to be presented. We wish that we could say that all the secrets of papermachine coating will be revealed, but until the patent situation has been cleared up this will not be possible. We hope that this will be done soon so that the literature on the subject can be brought up to date and the industry can proceed with the development of supersonic methods of coating application.

Supersonics

Now that we mentioned supersonics or ultrasonics we can report that we listened to a group of speakers talk on various aspects of this subject, recently. Every now and then one mentioned an application in pulp and paper mills. One speaker showed a photograph of pulp before and after it was exposed, supersonically. The product was fibrillated to a considerable extent. Other applications showed how fine dust particles in a recovery stack were agglomerated and collected and another showed how a proper interpretation of the impact of sound waves indicated the chances of heavy steel rolls holding together. As an auditor of the addresses, not the supersonic waves, which cannot be heard anyway, one gets the impression that the control of sound energy has many possibilities in industry. At present, however, the researchers are dealing with forces that are a little difficult to comprehend.

Statistics

In the March issue of *Tappi* Dr. Pascoe of the TAPPI Statistics Committee endeavored to explain statistical quality control, which is not quite as difficult to understand as supersonics. In the May issue the plain, ordinary statistics compiled by the Census Bureau will be published. These are of interest and value to all of us in orienting ourselves in our day-by-day jobs with the great industry of which we are a part.

Ten More Commandments

We might just as well join the procession of the scientific journals and reproduce the brain storm of Paul Entrikin of the Esso Standard Oil Company, published in *National Petroleum News*. Mr. Entrikin states that he prepared these precepts as a joke but it has now reached a point, having seen them published in so many places, that he is beginning to take them seriously.

TEN COMMANDMENTS FOR TECHNICAL MEN

I. Thou shalt not follow in the dust of progressing operations but shalt run ahead with a lantern in thy hand to reveal the way.

II. Thou shalt seek and respect the opinions of operators, even unto the third helpers, for theirs is a wisdom unknown to technocrats.

III. Thou shalt determine what should be done and do it without the necessity of others holding thy hand.

IV. Thou shalt not be too dignified to shoot the bull; neither shalt thou shoot it entirely, for so is its productivity destroyed.

V. Thou shalt not forsake the ways of thy technical training so that to thee CH_2O cease to be formaldehyde and become sea water.

VI. Thou shalt not take thy grievances and ideas first to the top lest the bottom remove its support from under thee, saying, "We know nothing of it."

VII. Thou shalt remember that refining processes change not because of reasoning and medication, however profound, but only by the turning of valves.

VIII. Thou shalt study thy conclusions from all sides through many viewpoints, for verily, undiscovered claws may rip thy rear.

IX. Thou shalt strive to make thy judgment as good as any man's by experimenting, observing, recording, calculating, studying, and thinking; and having done so,

X. Thou shalt use it.

Migration in the Industry

For many years the Association has published the directory changes of its members. This practice is being continued in *Tappi* under the general heading of Personal Mention. During the many years that these movements have been recorded not a single week has gone by during which some such changes were not reported. Sometimes these changes are from one paper mill to another. Again, there have been movements out of the industry, usually to companies that are selling products or services to the mills, and frequently, these same members move back into the industry. Each move has a story of its own. One does wonder, in these days, just where a migrator finds a place to live. Perhaps the man who left town provided an empty apartment.

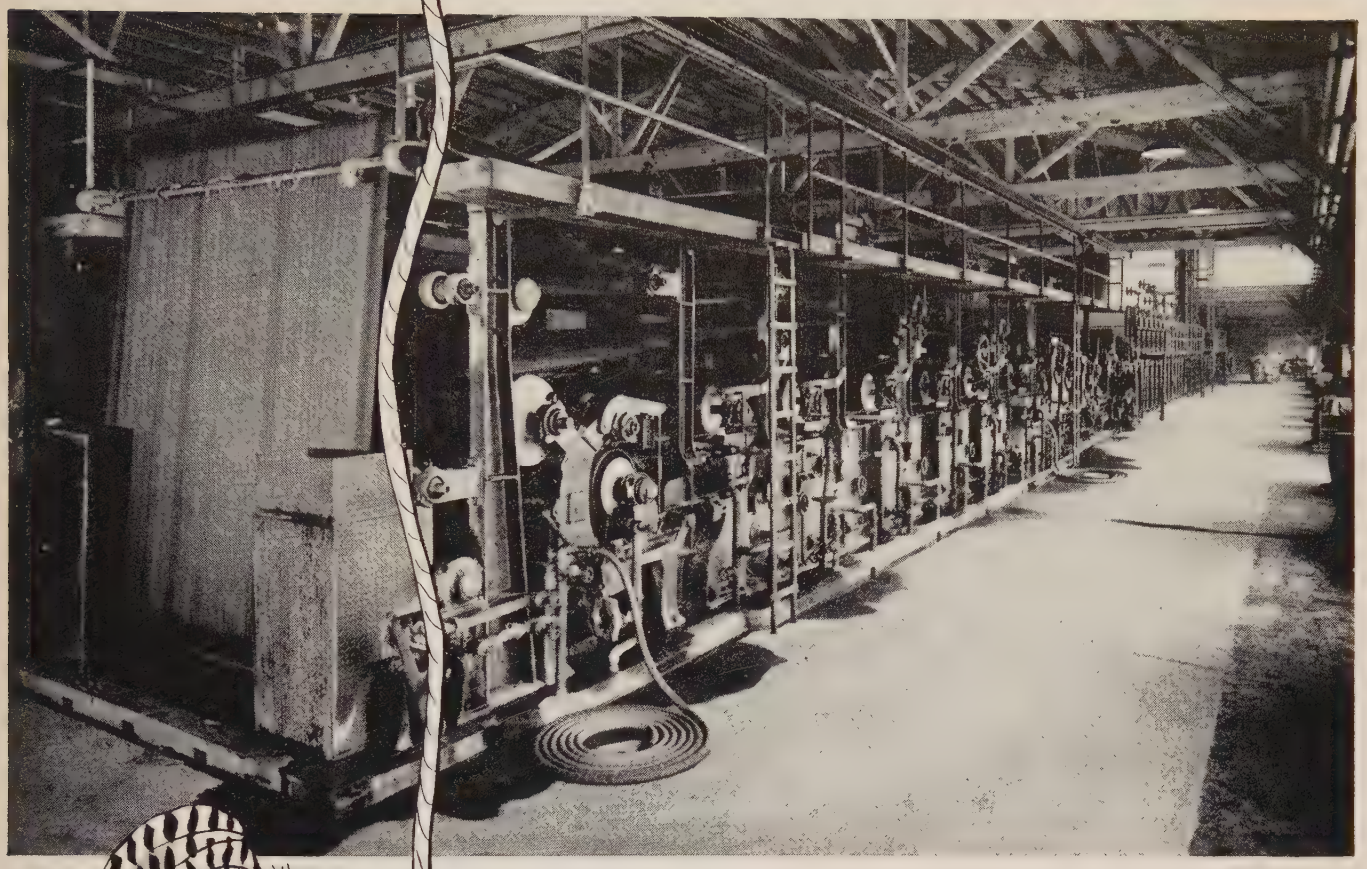
Acid Making for Sulphite

Usually book reviews appear in a different part of this magazine than the editorial section. Recently, however, a fine-appearaing cloth-bound book was published by the G. D. Jenssen Company, Watertown, N. Y., entitled "Acid Making in the Sulphite Pulp Industry," by A. H. Lundberg.

The publication of this book makes us a little envious because we wish that the Association could have issued it as one of its monographs. We were not asleep at the switch, since we proposed this to Mr. Lundberg when the contents of the book first appeared in serial form in *Pulp and Paper*.

(*continued on page 28 A*)

Magic in the Mill!



Indian rope tricks! Flying rugs! Bah! Can't hold a candle to what's right now being done in the modern paper mill.

A rope trick to end all rope tricks—a rope that grows right before your eyes—the Hydrapulper ragger.

A junk remover lugging brickbats out of a Hydrapulper—the busiest junk man that ever lived.

Ribbons of paper at sprinter speed—100 yards in 9.4 seconds and wide enough to blanket a highway.

Acres of machinery and combinations of machinery, all dancing to the tune played on a control board in some far-off control room.

Just a few Black-Clawson contributions to the magic of papermaking.

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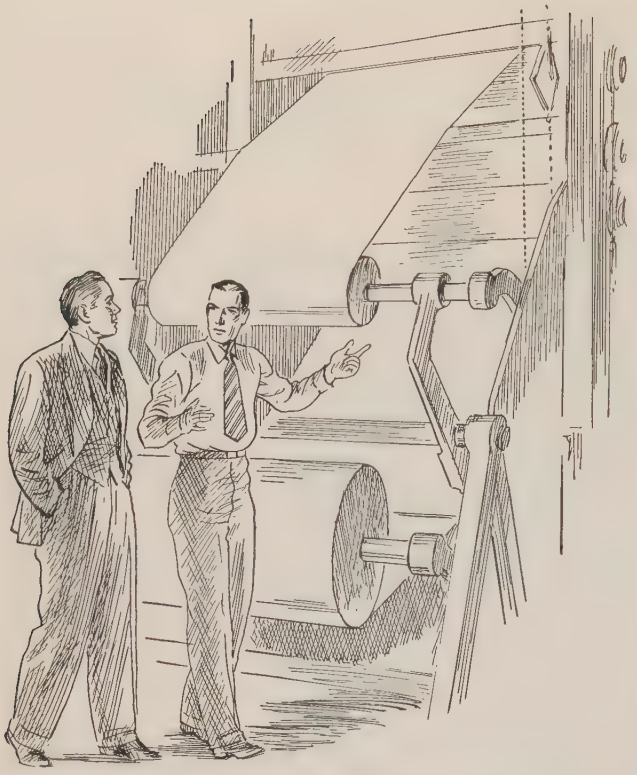

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Butterworth Calender Rolls

EDITORIAL COMMENT

(*continued from page 26 A*)

The book is a 53-page photo-offset job containing a mass of vital data, tables, and graphs on the subject. In the dedication, Mr. Lundberg extends his appreciation to G. D. Jenssen—his employer, teacher, and friend during the past 25 years, who made this publication possible. The volume is, in fact, a handbook covering raw materials, production of gas, combustion calculations, cooling of gases, solubility of gas, thermochemistry, etc. The G. D. Jenssen Company is making this book available for purchase at $6.00 per copy, plus mailing charges.

Congratulations to Mr. Lundberg and the G. D. Jenssen Company.

RECENT BOOKS

Modern Packaging Encyclopedia. Cloth $8^1/_4 \times 11^1/_4$, 994 pages, charts, illustrated. Domestic $6.50, Canada $9.00, Foreign $11.

For several years the Association has published a descriptive review, in the *TAPPI Bulletin,* of the Modern Packaging Encyclopedia. It is a book that serves its purpose well in bringing together a great amount of data each year relating to packaging materials of all kinds. In addition to its fine advertising coverage, which is educational in itself, because of the large number of samples shown, it also contains a number of specially prepared articles by experts in their respective fields. An interesting feature of the book is the large number of chart inserts. One of these is a tabulation of the properties of packaging papers. Among the major subjects covered are: Packaging in Specialized Fields, Materials of Packaging, Package Forms, Shipping Containers and Equipment, and Buyers Directory.

Copies may be purchased through the Book Department of *Tappi,* 122 East 42nd Street, New York 17, N. Y., at the above-mentioned prices.

Forest Products Research Society Proceedings, Vol. 2. Cloth $7^1/_2 \times 10^1/_2$, 495 pages, illustrated. For. Prod. Res. Soc., Box 2010, University Station, Madison 5, Wis. $8.00 (nonmembers).

A compilation of the 45 papers presented at the annual meeting of the Society, March 22–24, 1948 at Chicago, Ill. The contents include papers on chemical conversion of wood waste, mechanical conversion, bark removal and utilization, finishing of furniture, dielectric heating, etc.

Kinetics of Chemical Change in Solution. By Edward S. Amis, Louisiana State Univ. The Macmillan Co., New York, N. Y. Cloth $5^1/_2 \times 8^1/_4$, 332 pages, illustrated. $5.00.

An advanced text for research men interested in the fundamentals of kinetics of reactions in solution, both theoretical and applied. Among the subjects covered are: The Debye-Hückel Theory, the Temperature Coefficient of Reaction Rates; Reactions Between Ions and Dipolar Molecules; Reaction Rates and the Solvent; Adsorption, and Homogeneous Catalysis.

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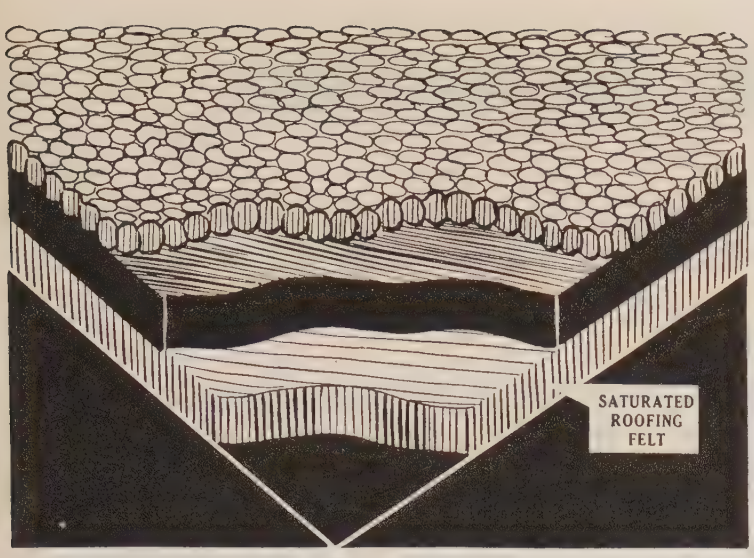

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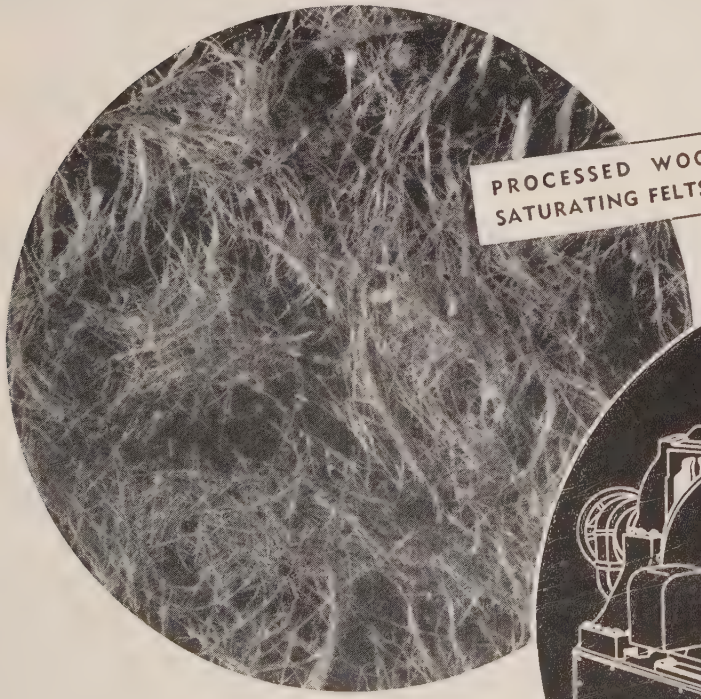
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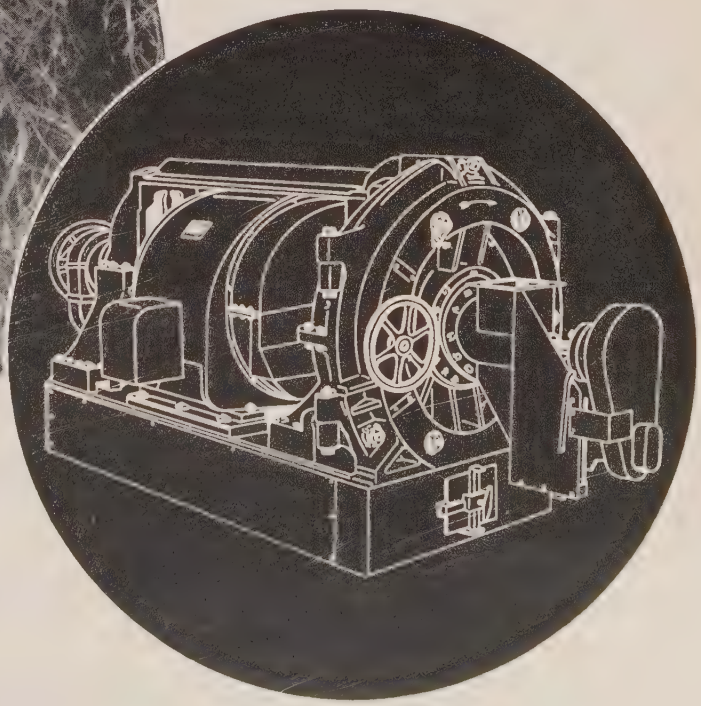

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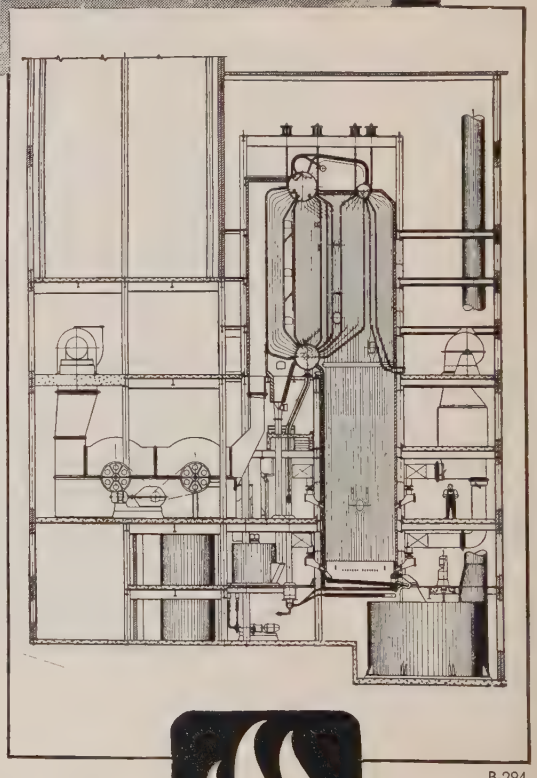
45

One of Canada's Largest Recovery Units now in Service at LongLac Mill

The new mill at Terrace Bay, Ontario. The building in the foreground houses the C-E Recovery Unit.



B-294

The LongLac Pulp & Paper Company, Limited, subsidiary of the Kimberly-Clark Corporation, recently placed in service their new pulp mill at Terrace Bay, Ontario, Canada.

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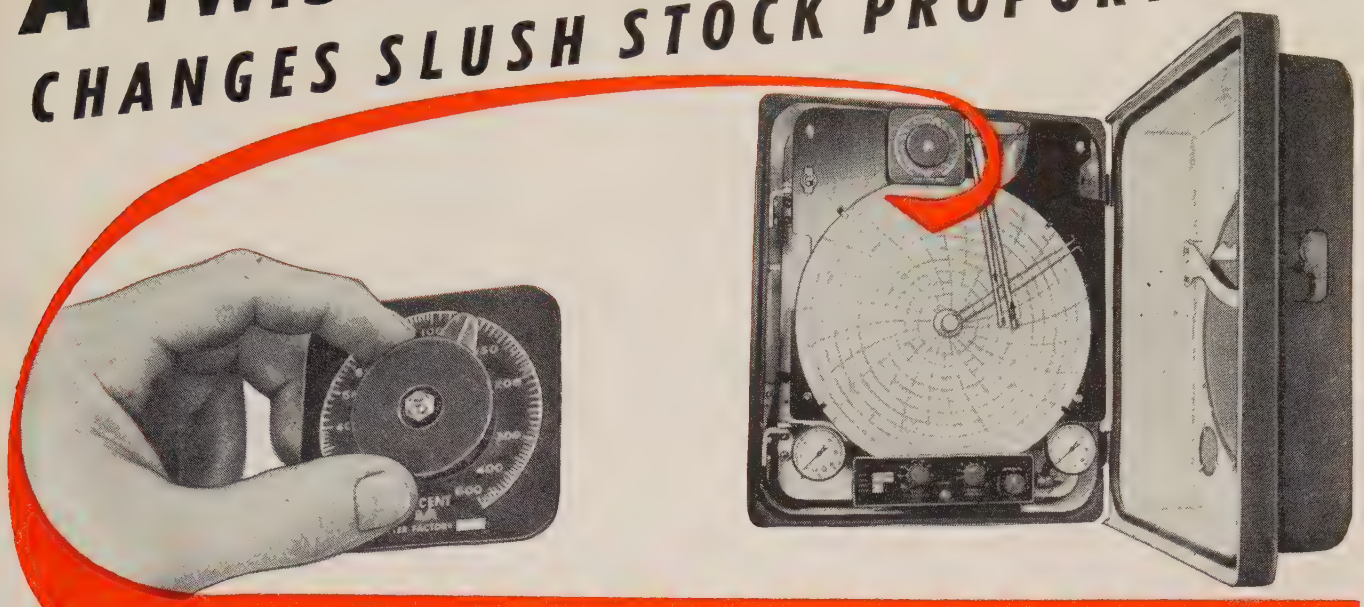
A TWIST OF THE WRIST CHANGES SLUSH STOCK PROPORTIONS



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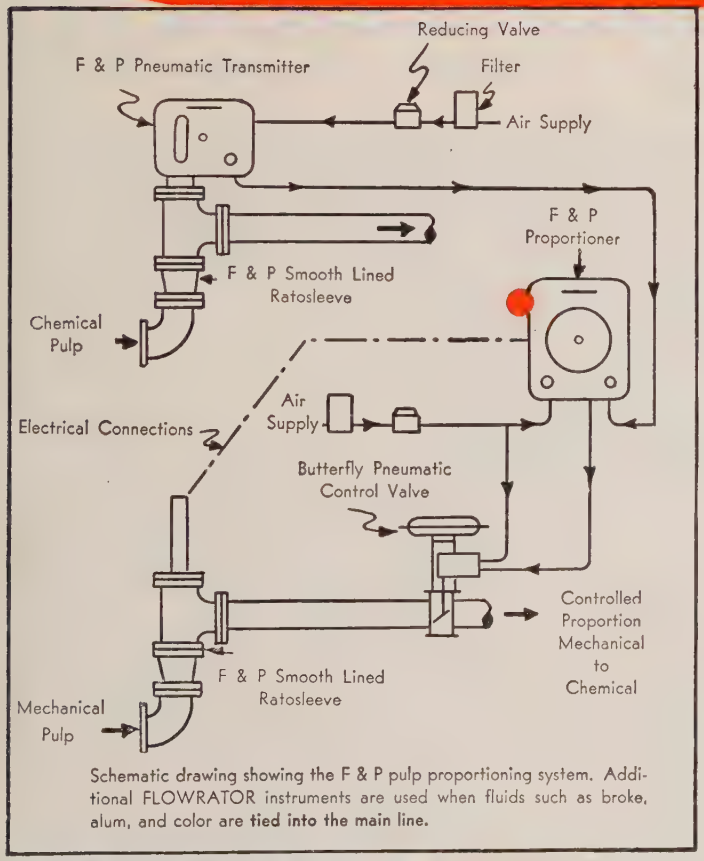

Schematic drawing showing the F & P pulp proportioning system. Additional FLOWRATOR instruments are used when fluids such as broke, alum, and color are tied into the main line.

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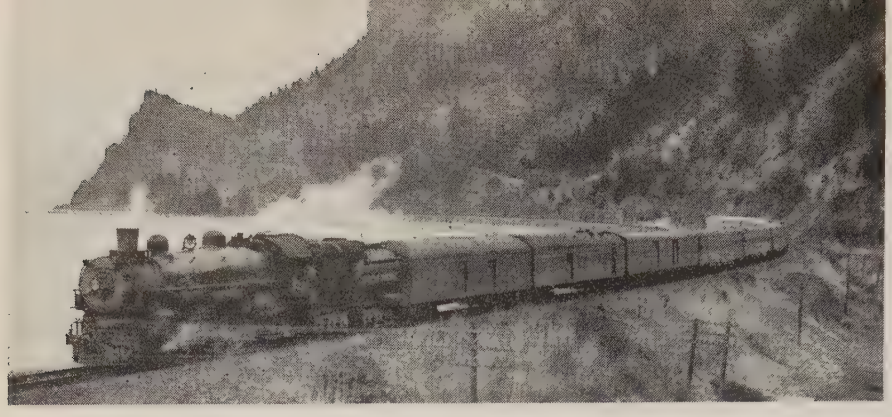

Winding down the Columbia River as the TAPPI Special Train Nears Portland

All Aboard . . . for the Greatest Fall Meeting of TAPPI in History

For the second time in history pulp and paper makers and those allied with the industry will converge on Portland, Oregon, September 11th to 15th for the Annual Fall Meeting of TAPPI. Members of TAPPI are urged to make their reservations on the TAPPI Special train as soon as possible to insure adequate accommodations for it is going to be a never-to-be-forgotten trip out over the historic Union Pacific route.

A second train call will not be necessary for the old-timers who travelled out on the TAPPI Special train in 1934 and again in 1940 to the Coast meetings. They have spread the word in all divisions of

One full day in this beauty of the West . . . . . SUN VALLEY

TAPPI that a Fall Meeting on the Pacific Coast is something *not to be missed.* And the members of the Pacific Coast Section, oldest division of TAPPI, acting as hosts for the occasion under the co-chairmenship of A. G. "Buff" Natwick, assistant resident manager of Crown Zellerbach's largest mill at Camas, Washington, and Russell J. LeRoux, manager of the Everett, Washington pulp mill of Weyerhaeuser Timber Company, have prepared a program of technical sessions,

A. G. Natwick, Co-chairman Fall Meeting: Assistant Resident Manager, Crown - Zellerbach Corp., Camas, Wash.

woods trip, mill visits, entertainment and travel that is certain to eclipse those of past years.

Train accommodations will be of the very finest. Leaving Chicago Thursday, September 8th at 3:00PM, you will enjoy every minute of the journey that will carry you through Illinois, Iowa, Nebraska, Colorado, Wyoming, Idaho and into Oregon. Just imagine the fun you can have from 7AM until 9:00PM at SUN VALLEY on Saturday. Then on Sunday from 2PM until 3:30PM stretch your legs at the $50,000,000 Bonneville Dam, where the U. S. Army Engineers will provide a personally conducted tour over this mammoth hydro-electric installation. See the Columbia River salmon fighting their way up the fish ladders at the Dam. At 4:30PM, as the TAPPI SPECIAL TRAIN rolls into Union Station in Portland, what a royal welcome you will get from the special committee of Portlanders.

Portland, Oregon, the City of Roses and scene of the 1949 Fall Meeting of TAPPI

And from this point on, the advance work of eleven committees will, under co-chairmen Natwick and LeRoux, be revealed in a smoothly running series of events that will include mill visits arranged so you may select your choice from among six of the most modern in the country: a day in the woods where you will see the biggest trees in the world used for making woodpulp, tree farms and selective logging and two days of technical papers and discussions.

There will be time for relaxation and social events and here as in the balance of the program being built for your practical benefit, the entertainment will be truly western style.

Portland and vicinity has many places to go to and things to see of great scenic beauty. The ladies will be royally entertained and promised a full schedule of functions. There will be luncheons, fashion teas, and a trip to beautiful Timber-

Bonneville Dam on the Columbia River at a cost of $50,000,000 . . . . just up river from Portland

line Lodge on snow-capped Mt. Hood, via bus and sky lift.

So, "YES, GO WEST" to the Fall Meeting of TAPPI in Portland in September.

For TAPPI SPECIAL Train Reservations: Write to Mr. John C. Pollock, General Passenger Agent, Union Pacific Railroad, One South LaSalle Street, Chicago 3, Illinois.

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R. J. LeRoux, Co-chairman Fall Meeting; Resident Manager, Weyerhaeuser Timber Company, Pulp Div., Everett, Wash.

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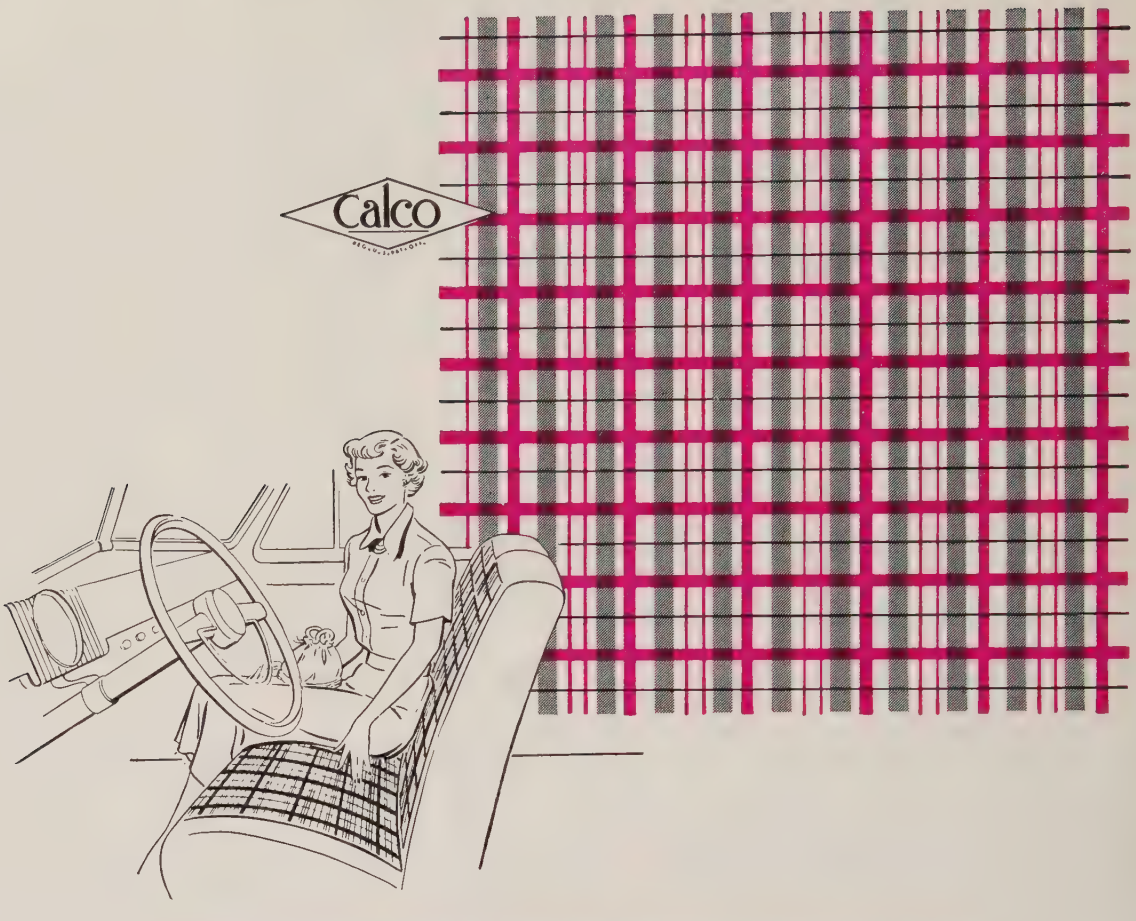

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A New Mechano-Chemical Process for Pulping Agricultural Residues

S. I. ARONOVSKY and E. C. LATHROP

A new process has been developed for pulping agricultural residues involving combined and simultaneous chemical and mechanical action on the raw material at atmospheric pressure and at temperatures at or near 100°C. Excellent strawboard pulps were produced by cooking wheat straw for one hour in a laboratory hydrapulper using the normal amounts of chemicals. Strong, easy-bleaching kraft straw pulps were made in a half-hour cooking period in this equipment. Reuse of the kraft black liquor from the hydrapulper for three successive subsequent cooks had no appreciable effect on the yields or properties of the resulting pulps. The final black liquor contained more than 7% of organic matter. A possible explanation for the rapid pulping action in the hydrapulper is given. The significance of these preliminary results and the advantages of this method of pulping are discussed. This mechano-chemical process might have considerable influence in increasing the use of agricultural residues for paper, board, and their products.

EASY-bleaching pulp can be prepared from straw by cooking it in an open vessel at or near 100°C. for about one-half hour. Strawboard pulp is produced similarly in about one hour. In both types of cooks the chemical requirements are the same as, or less than, those normally used in pressure pulping. These revolutionary results were accomplished in the Northern Laboratory with the use of a small experimental hydrapulper.

Previous work with an experimental hydrapulper by one of the strawboard mills had shown that whole straw could be chopped effectively in the presence of cold water in this equipment. The straw pieces were also split longitudinally at the same time. The chopping action was not as efficient in hot water because the softened and wilted straw tended to intertwine and knot together.

Similar results in wet chopping of straw in a small hydrapulper were obtained in this Laboratory. When this wet-chopped straw was cooked with 6.0% lime and 1.5% caustic soda for five hours at 140°C. (40 p.s.i.) the pulp was similar in all respects to that produced from whole straw under comparable conditions.

Attempts were then made to impregnate the wet-chopped straw with hot water containing the pulping chemicals prior to cooking it in the autoclave. The very rapid softening of the straw in the hot liquor in the hydrapulper indicated the possibility of completing the pulping in this equipment. When an apparently satisfactory strawboard type of pulp was produced after one hour's treatment in this machine, a series of cooking experiments was carried out on producing both strawboard type pulp and bleachable fine pulp. This paper reports the results of these preliminary pulping studies.

S. I. ARONOVSKY, Member TAPPI, In Charge, Pulp and Paper Section; E. C. LATHROP, Member TAPPI, Head, Agricultural Residues Division, Northern Regional Research Laboratory, Peoria, Ill. One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

EXPERIMENTAL

The raw material used was soft winter wheat straw (Kawvale variety, grown in central Illinois in 1945) from the same batch reported on in earlier work (*1*). The dry-chopped straw, 1 to 3 inches long, was produced with an ensilage cutter with spiral lawnmower-type blades. The dry-chopped straw was dusted on a 20-mesh vibrating screen before use, to remove dust and dirt.

The experimental machine was a 3-foot unit with an 18-inch propeller plate on which were welded a number of vanes $^1/_2$ inch high. The unit was connected to a 25-hp. motor through 3-sheave pulleys, and the propeller attained a calculated peripheral speed of about 3800 f.p.m.

Pulping Procedure

The hydrapulper was generally loaded first with hot water or hot cooking liquor. Rotation was started and then the straw was added as rapidly as possible. Direct steam was used for pulping, and the cooking period was measured from the time the last of the straw was added. Samples were removed frequently from the hydrapulper during the cooking and examined visually for degree of pulping; the pulping was considered complete when the sample appeared to be fairly well defibered. At the end of the cook the pulped straw was removed from the hydrapulper and washed. It was then defibered, if necessary, in an experimental Noble and Wood beater, in a 24-inch Bauer pulper, or in the hydrapulper. The defibered material was tested in the Valley standard beater. The fine pulp, in contrast to the strawboard pulp, was screened before it was tested for strength characteristics.

Strawboard and fine straw pulp were also prepared by the pressure-pulping methods to serve as reference materials.

The data on straw cooking and processing and on pulp testing are given in Tables I to VIII. The tests were made in accordance with the TAPPI standards.

Strawboard Pulp

The pulping conditions and yields of strawboard pulps are shown in Table I. It is evident, from these data, that the yields of pulp produced at atmospheric pressure by this process are at least as large as those obtained by pressure pulping. At the same time the high pH of the black liquor from the atmospheric cooks indicates that the active chemicals were not completely exhausted.

The type of defibering had no apparent effect on

Table I. Straw Preparation, Cooking Conditions, and Pulp Yields in the Mechano-Chemical Production of Strawboard Pulp

Cook no.	Chopping		Cooking				Pulp yields			Power, hp./ton pulp/day		
	Type[a]	Time, min.	Time, hr.	Temp., °C.	Consistency, %	pH final liquor	Crude, %	Washed, %	Fines, %	Chopping	Pulping	Total
662	D	..	5.0	140	14.1	8.8	80.1[b]	75.3	4.8	..	..	..
663	..	..	5.0	140	14.1	8.9	83.2[b]	77.9	5.3	..	..	..
678	W	12	1.0	95–98	3.0	11.4	81.1[c]	75.9	5.2	7.0	30.2	37.2
							82.0[b]	75.8	6.0			
683	D	..	1.0	91–98	8.0	11.1	83.0[b]	78.0	5.0	..	39.3	39.3
							84.1[c]	79.1	5.0			
687	W	17	0.5	90–98	5.0	11.4	81.9[b]	77.6	4.3	14.9	27.0	41.9
							80.7[c]	77.8	2.9			

[a] D = dry chopping; W = wet chopping.
[b] Defibered and washed in Noble and Wood beater.
[c] Defibered in Bauer pulper, washed in Noble and Wood beater.

pulp yield, whether it was accomplished in the Bauer pulper or the Noble and Wood beater. This indicated that the pulps from cooks 678, 683, and 687 were probably closely similar in their fiber properties since previous work had shown that Bauering a hard brittle pulp produces less washed pulp and more fines than are obtained with a softer pulp.

The power required for producing pulp from straw in the hydrapulper, as shown in Table I, increased with the consistency of the straw or pulp suspension. These power values, obtained with a recording wattmeter, are fairly high, but it is expected that with larger units the power requirements per daily ton would be relatively lower.

The outstanding differences between the pressure digestion and hydrapulper methods of cooking are found in the temperatures and time periods required for pulping the straw. The lower cooking temperature for shorter periods required in the hydrapulper process should result in a considerable saving of steam. The reduction in cooking time from an average of five hours to about one hour should also produce large savings per unit of production, not only in labor required but also in fixed charges, such as interest, lower insurance rates (no pressure equipment), etc.

The hydrapulper-digested strawboard pulps had somewhat better beating and strength characteristics, particularly bursting strength and tear resistance, than the pressure-cooked pulps, as shown in Table II. These higher values were also obtained at generally higher freeness, indicating that these pulps could probably be made into paper at greater machine speeds. The somewhat higher apparent density of the hydrapulper pulps is probably due to better delignification of these pulps as compared with the pressure-cooked pulps and, consequently, to better hydrating and felting characteristics of the resulting fibers. This is borne out by the chemical analyses of these pulps (Table III) which show the lower lignin and higher pentosan contents of the pulps prepared in the hydrapulper. The color of the strawboard pulp prepared at atmospheric pressure was somewhat darker than that of the original straw, but much lighter than the color of pressure-cooked pulp.

Fine Straw Pulp

Experiments on producing fine pulp from straw in the hydrapulper were made with sodium sulphite and with kraft chemicals. The cooked residues were defibered in the Bauer pulper prior to screening and determining yields. The neutral sulphite process did not work too well on straw at atmospheric pressure. This is shown by the relatively long time required to produce a pulp in the hydrapulper, as indicated in Table IV (cook 690). Although the yield of pulp from this cook was high, its relatively low strength properties (Table V) and high lignin content (Table III) characterize it as a raw pulp, when compared with the regular, pressure-cooked wheat straw pulp (cooks 672–677). It is apparent that, for practical purposes, sodium sulphite is too mild an agent for use in pulping straw at the temperatures produced by steaming at atmospheric pressure.

The results with strong pulping agents such as the caustic soda and sodium sulphide of kraft liquor were considerably different from those obtained with neutral sulphite. The data in Tables IV and V show that with 12% of kraft chemicals, based on dry straw, a much larger yield of screened pulp was obtained by digesting straw for one-half hour in the hydrapulper at 98°C. than by cooking for two hours at 170°C. (100 p.s.i.). The beating and strength characteristics of these two pulps (cooks 594 and 691) were very similar, except for folding endurance. The lower folding endurance and lower apparent density of the hydrapulper kraft pulp indicate that this pulp was somewhat harder than the pressure-cooked pulp. This fact is corroborated by the higher permanganate num-

Table II. Beating and Strength Characteristics of Mechano-Chemical Strawboard Pulps

Cook no.	Beating time, min.	Freeness S.R., ml.	At maximum burst: Basis weight (25 × 40—500), lb.	Bursting strength, pt./ream lb. × 100	Tensile strength, g./ream lb.	Tear resistance, g./ream lb. × 100	Crush resistance (Riehle), lb.	Apparent density, g./ml.
662[a]	45	345	120	60	115	47	44	0.62
663[b]	45	300	119	60	129	50	41	0.70
678[d]	30	445	117	72	124	65	33	0.68
678[c]	30	405	119	63	133	56	44	0.76
683[c]	45	340	119	66	126	62	43	0.72
683[d]	45	260	120	67	136	54	49	0.81
687[c]	30	580	120	67	124	81	41	0.68
687[d]	30	430	116	65	129	69	40	0.72

[a] Standard pressure-cooked pulp, dry-chopped straw.
[b] Standard pressure-cooked pulp, whole straw.
[c] Defibered and washed in Noble and Wood beater.
[d] Defibered in Bauer pulper, washed in Noble and Wood beater.

Table III. Chemical Constants of Pressure- and Hydrapulper-Digested Straw Pulps

Cook no.	Type	Equipment	Permanganate no.	Bleachability,[a] %[b]	In pulp: Lignin, %[b]	In pulp: Pentosans, %[b]	In pulp: Ash, %[b]
662	Strawboard	Pressure digester	..	..	17.7	26.8	8.7
663	Strawboard	Pressure digester	..	..	17.8	24.2	9.2
678	Strawboard	Hydrapulper	..	..	15.9	29.9	7.6
683	Strawboard	Hydrapulper	..	..	15.6	30.4	11.5
687	Strawboard	Hydrapulper	..	..	16.0	32.1	11.6
672–677	Na_2SO_3 (8%)	Pressure digester	15.5	6.9	4.3	27.1	8.6
690	Na_2SO_3 (12%)	Hydrapulper	46.8	25.0	11.6	33.3	3.5
594	Kraft (12%)	Pressure digester	13.1	6.6	4.0	30.1	4.9
691	Kraft (12%)	Hydrapulper	20.7	13.7	6.1	32.5	1.9
694	Kraft (10%)	Hydrapulper	27.1	18.8	7.6	33.6	1.6
692	Kraft (8%)	Hydrapulper	28.2	17.8	8.8	32.6	2.7
693	Kraft (6%)	Hydrapulper	34.4	24.4	11.0	33.5	3.7
694	Kraft (10%)	Hydrapulper	27.1	18.8	7.6	33.6	1.6
695	Kraft (10%)	Hydrapulper	27.3	18.5	7.7	32.6	2.0
696	Kraft (10%)	Hydrapulper	29.1	18.1	8.2	32.9	2.3
697	Kraft (10%)	Hydrapulper	27.5	17.8	7.9	31.5	2.5

[a] Consumption of available chlorine in single-stage bleaching to give a pulp brightness of 70%.
[b] Based on moisture-free unbleached pulp.

ber and lignin content of the hydrapulper pulp, as given in Table III. The lower folding endurance of the atmospheric pulp is not very critical, however, since, as has been shown previously, this value can be increased considerably by further delignification through multistage bleaching, with simultaneous improvement of the other strength characteristics of the pulp. The hydrapulper kraft pulp had a much lighter color than that of the usual pressure-cooked kraft straw pulp.

Decreasing the amount of kraft chemicals used for cooking in the hydrapulper resulted in increasing the time required to produce a pulp. The decrease in cooking chemical also gave increased yields of crude pulp, as expected. The variations in the yields of screened pulp, screenings, and fines, as shown in Table IV, are probably due to the differences in clearance between the plates of the Bauer used for defibering the crude pulps. The strength values of these screened pulps (Table V) dropped, however, and the lignin content and permanganate number (Table III) increased regularly with decreasing chemical used for pulping. The ash contents of the hydrapulper kraft pulps increased with decreasing pulping chemical, but they were all lower than the ash of the pressure-cooked pulp. The concentration of cooking chemical had practically no effect on the pentosan contents of the pulps. It must be noted here that these pentosan contents were very high, thus emphasizing the fact that the hydrapulper process approaches the ideal in pulping—delignification with relatively little action on the carbohydrate portion of the plant material.

Since the hydrapulper cooks must be carried out at lower consistencies than those used in pressure cooking, the concentration of organic materials in the black liquors of the low-temperature cooks is fairly small. However, if the black liquors could be reused for pulping, it might be possible to build up the concentration of the organic material to the point where chemical recovery would be feasible. A series of four cooks was therefore made in the hydrapulper, with 10% kraft chemicals for the first cook. The drain liquor from this cook plus the liquor pressed from the pulp was used for the succeeding cook, more chemical being added to bring the total to 10% of the straw. This procedure was repeated twice more. The pulping and yield data are given in Table VI, and the strength tests on the pulps in Table VII. The chemical characteristics of these pulps were quite similar (Table III) except for the ash content which increased some with repeated reuse of the waste liquor. These results indicate that reuse of the black liquor had but little effect on the yields or strength properties of the pulps under the conditions used in these experiments.

The increase in total and volatile solids and inorganic matter of the black liquor from these cooks is shown in Table VIII. The concentration of volatile solids (organic matter) after the third reuse of the liquor (cook 697) approaches the range where evaporation and burning of this black liquor may be practical. Although these results are too meager to be conclusive, they do indicate that black liquor can be reused for kraft cooking in the hydrapulper, and that recovery of the chemicals and heat values from this black liquor might be feasible.

GENERAL CONSIDERATIONS

Although it has been known for a long time that

Table IV. Cooking Conditions and Pulp Yields in Mechano-Chemical Production of Kraft Straw Pulps

Cook no.	Cooking: Chemicals[a] Na_2SO_3, %	Cooking: Chemicals[a] Na_2CO_3, %	Cooking: Time, hr.	Cooking: Temp., °C.	Liquor pH: Initial	Liquor pH: Final	Consistency, %	Bauer clearance, in.	Yields[a]: Crude pulp, %	Yields[a]: Screened pulp, %	Yields[a]: Screenings, %	Yields[a]: Fines, %	Hydrapulper power, hp./ton pulp/day
672–677	8.0	3.0	2.0	170	10.1	7.8	14.1	...	61.6	54.2	2.7	4.7	...
690	12.0	3.0	6.0	98	..	9.4	6.0	0.013	71.6	66.1	1.4	4.1	202.0
	NaOH	*Na_2S*											
594	8.0	4.0	2.0	170	..	9.9	14.1	...	53.8	47.4	1.0	5.4	...
691	8.0	4.0	0.5	92–98	12.0	11.7	6.5	0.025	61.1	59.5	0.7	0.9	22.5
694	6.7	3.3	0.75	93–98	12.0	11.1	7.5	0.035	63.4	55.3	4.1	4.0	32.3
692	5.3	2.7	1.0	93–98	..	..	8.5	0.020	66.6	63.5	0.4	2.7	37.8
693	4.0	2.0	2.5	91–98	11.8	9.8	6.0	0.025	69.1	60.2	3.0	5.9	103.5

[a] Based on original moisture-free straw.

Table V. Beating and Strength Characteristics of Mechano-Chemical Kraft Straw Pulps

Cook no.	Beating time, min.	Freeness S.R., ml.	At maximum burst: Basis weight (25 × 40—500), lb.	Bursting strength, pt./ream lb. × 100	Tensile strength, g./ream lb.	Tear resistance, g./ream lb. × 100	Folding endurance, double folds	Apparent density, g./ml.
672–677	60	390	47	94	174	54	351	0.89
690	60	395	46	70	147	40	22	0.64
594	45	370	47	103	194	38	1010	0.93
691	45	340	45	101	192	37	477	0.84
694	45	330	48	104	202	33	356	0.89
692	45	330	47	94	179	34	358	0.74
693	45	350	47	91	186	34	218	0.76

agricultural residues such as straw could be pulped at atmospheric pressure, relatively large amounts of chemicals and long cooking periods were required. The astonishingly rapid production of good pulps with relatively low chemical usage, as described in these experiments, was therefore quite unexpected. The explanation for these results probably lies in the simultaneous mechanical and chemical action on the straw in the hydrapulper.

The reaction between a pulping agent and the plant material to be delignified may be considered as a topochemical reaction; that is, it takes place at the contact surface or interface between the solid plant material and the liquid containing the active chemical. When the reaction at this point is completed no further action takes place until the reaction products have been removed, thus exposing fresh surfaces. This is readily accomplished during the early part of a cook by circulation of the liquor past the more or less stationary plant material in a stationary digester, or by the difference in motion of the liquor and plant material, relative to each other, in a tumbling or rotating digester. After the first rapid action on the outside surfaces of the solid material, the reaction products from the inner surfaces have to be removed and replaced by fresh liquor. This exchange at the reacting inner surfaces takes place through the slow medium of diffusion. It is mainly for this reason that the rate of pulping decreases as the cooking progresses, and that dense material such as wood chips requires preliminary impregnation with the cooking liquor.

In the hydrapulper the rate of diffusion is greatly increased by the mechanical impact of the rotating vanes on the liquid-soaked straw. When the vanes hit the straw, the impact compresses the turgid material, causing some of the liquid to be squeezed out, much as one would squeeze liquid from a sponge. After leaving the zone of impact, the straw tends to recover its original volume and takes up about as much liquid as it lost on impact with the vane. Thus, diffusion of the chemical-containing liquid in and out of the straw is speeded up greatly by the mechanical action of the hydrapulper resulting in the rapid pulping rates observed in these experiments.

This rapid increase in rate of diffusion can also be accomplished by other mechanical devices. A fairly satisfactory pulp was obtained by mixing dry-chopped straw at about 3% consistency, in hot kraft liquor in an open bucket, with a high-speed propeller stirrer. It took longer to produce pulp in this bucket than in the hydrapulper and it is probably not a very practical pulping method. This experiment served, however, to confirm the pulping principle described.

If this explanation is correct it can be readily seen that it would not be feasible to pulp wood in chip form by this process. It should be possible to use this method, however, for pulping fine wood excelsior or coarse wood fibers such as those produced for insulating or building board. The hydrapulper method should also be useful for pulping nonwoody fibers such as flax and hemp tow, cotton, sugarcane bagasse, cornstalks, jute, reeds, manila and sisal fiber.

The results reported here must be considered as merely preliminary, since only a few experimental laboratory runs were made. If these data are corroborated by further laboratory and commercial-scale tests, however, they may revolutionize pulping techniques and equipment, particularly those used for agricultural residues. The rapidity of pulping straw at atmospheric pressure by this process would overcome the present disadvantage of low density of this residue as compared with wood which results in lower production per digester. The process of digestion could be streamlined and possibly made continuous with simpler and better control than is possible with the present pressure-cooking methods.

The preliminary chopping of straw as a separate step prior to cooking could probably be eliminated. Whole straw fed into the hot liquor in the hydrapulper was transformed into pulp almost as readily as prechopped straw. Apparently the hot liquors not only wilt the straw rapidly, but also soften it sufficiently so that it may be torn apart easily by the action of the propeller vanes.

Table VI. Effect of Reuse of Black Liquor on the Cooking Constants and Pulp Yields of Mechano-Chemical Kraft Straw Pulps

Cook no.	Cooking: Chemicals added[a] NaOH, %	Na₂S, %	Time, hr.	Temp., °C.	Liquor pH: Initial	Final	Yields[a, b]: Crude pulp %	Screened pulp, %	Screenings, %	Fines, %	Hydrapulper power[c], hp./ton pulp/day
694	6.7	3.3	0.75	93–98	12.0	11.1	63.4	55.3	4.1	4.0	32.3
695[d]	6.0	2.6	0.75	93–98	12.2	11.1	64.1	57.6	3.6	2.9	37.4
696[e]	6.7	2.1	0.75	95–98	12.2	11.1	65.8	58.4	3.3	4.1	34.1
697[f]	6.7	2.3	0.75	93–98	12.2	11.1	65.5	59.7	2.8	3.0	42.0

[a] Based on original moisture-free straw.
[b] Bauered at 0.025-inch clearance between the plates.
[c] Consistency 7.5%.
[d] First reuse of black liquor.
[e] Second reuse of black liquor.
[f] Third reuse of black liquor.

Table VII. Effect of Reuse of Black Liquor on the Beating and Strength Characteristics of Mechano-Chemical Kraft Straw Pulps

Cook no.	Beating time, min.	Freeness, ml.	At maximum burst: Basis weight (25 × 40—500) lb.	Bursting strength, pt./ream lb. × 100	Tensile strength, g./ream lb.	Tear resistance, g./ream lb. × 100	Folding endurance, double folds	Apparent density, g./ml.
694	45	330	48	104	202	33	356	0.89
695[a]	45	330	48	107	199	35	395	0.88
696[b]	45	280	48	107	199	35	344	0.88
697[c]	45	320	47	101	186	35	253	0.82

[a] First reuse of black liquor.
[b] Second reuse of black liquor.
[c] Third reuse of black liquor.

The nodes and rachises in straw have always been troublesome to the pulpmaker. They do not cook as readily as the culm or stem. The usual pulp beating and refining methods break down these softened nodes and rachises to small particles which are not easily bleached and show up as specks in the final paper, and to the ultimate platelets and cells which slow down paper machine operation. The process of blowing the cooked straw from the digester, previously developed in this Laboratory, shatters the node and rachis materials to very small particles which can be partly removed by screening or deckering. However, a portion of these particles naturally remains in the straw pulp.

In the hydrapulper, the nodes and rachises were swollen and softened but not disintegrated. When pulping was completed these nodes and rachises had only a few straw fibers still clinging to them. Removing the pulped straw from the hydrapulper and returning it to this machine after washing out the black liquor, and recycling in water for a few minutes resulted in complete defibering of the pulp and removal of most of the fibers clinging to the nodes and rachises. This recycling treatment eliminated the need for other defibering equipment. The practically fiber-free nodes and rachises were then almost completely removed by riffling, followed by screening on 8-cut plates. A large proportion of the grain seeds normally present in straw and usually digested and disintegrated by the presently used pulping and refining methods were also retained in the riffler and on the flat screen, in a swollen and softened condition. The resultant riffled and screened pulp had a somewhat lower lignin content, better bleachability, and fewer specks than a similar pulp which had been defibered in a beater or disk refiner before riffling and screening.

Pulping agricultural residues in a hydrapulper, or other equipment which has similar mechanical action would, if successful, have many advantages over the present methods of pressure pulping. Among these are: (a) elimination of pressure vessels, with the consequent reduction in equipment cost, safety hazards, and insurance rates; (b) reduction of steam consumption; (c) reduction in pulping time, resulting in a saving of labor, and fixed and other charges per unit of production; (d) simpler and easier control of operations with the attendant improvement in quality and uniformity of production; (e) production of larger yields of pulp with higher hemicellulose content, requiring less power and equipment for beating and refining; (f) practically complete separation of node and rachis material and seeds from the pulp, resulting in improved quality of product; and (g) complete defibering of the pulp with minimum production of fines.

Table VIII. Effect of Reuse of Black Liquor on Its Content of Total Solids, Volatile Solids, and Ash

Cook No.	Total solids[d] %	Volatile solids[d] %	Ash[d] %
694	4.6	3.0	1.6
695[a]	6.9	4.7	2.2
696[b]	8.3	5.8	2.5
697[c]	10.1	7.3	2.8

[a] First reuse of liquor.
[b] Second reuse of liquor.
[c] Third reuse of liquor.
[d] Based on the weight of black liquor.

SUMMARY AND CONCLUSIONS

1. A series of cooks at atmospheric pressure, made in a laboratory hydrapulper, produced excellent strawboard type and fine chemical pulps from wheat straw in astonishingly short cooking periods.

2. Cooking for one hour at 90 to 98°C. in the hydrapulper gave strawboard pulps with yields and physical properties at least as good as those obtained by cooking for five hours at 140°C. (40 p.s.i.) with the same amounts of chemical.

3. Higher yields of kraft straw pulps were produced by a one-half-hour treatment in the hydrapulper than by a two-hour cook at 170°C. (100 p.s.i.). The physical properties of the hydrapulper product were fully as good as those of the pressure-cooked pulp. Higher pentosan and lower ash contents characterized the hydrapulper products.

4. Reusing the kraft black liquor from the hydrapulper in three successive subsequent cooks had but little effect on the yields and properties of the resultant pulps.

5. The significance of these results is discussed, including a possible explanation for the rapid pulping action of the hydrapulper.

6. These preliminary studies with the hydrapulper, if confirmed by larger-scale tests, might revolutionize the techniques of pulp production particularly from agricultural residues.

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Mention of trade names, their equipment, or products is for information only and does not constitute an endorsement.

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Groundwood for Newsprint

Effect of Grinder Operation on Printing Quality

R. T. WETMORE and L. W. DUNPHY

This subject is considered with reference to grinder operation at the Anglo-Newfoundland Mill at Grand Falls, Newfoundland. Connection is shown between groundwood quality and paper quality, and changes required in grinder equipment and practice to obtain certain changes in quality of the resulting sheet are discussed.

Ink absorbency of the sheet is related to the resin content of the groundwood, which can be controlled within limits by the grinding temperature. The use of alum in the paper mill furnish, in the presence of large percentages of resin, can also have an effect on ink absorbency.

The effect on the hardness and bulk of the sheet from changes in groundwood freeness, and from changing from natural to artificial stones, is discussed, along with certain aspects of control of groundwood quality..

For many years those in the business of making paper have heard the trite saying: "Paper is made in the beaters." Nowadays the beater is seldom used in newsprint mills, except at times as a disintegrator for bales or broke, and the old saying can be changed to read: "Paper is made in the groundwood mills," at least so far as modern newsprint manufacture is concerned. It simply means that unless groundwood of the proper grade is produced for the paper mill, a maximum production of good quality paper cannot be achieved.

Before 1940 the Anglo-Newfoundland Development Company was making paper almost exclusively for the English market. Increasing shipping difficulties, due to war conditions, forced the transfer of a large part of the mill production to the American continent, and this mill has been largely selling in the American market since that time. It quickly became evident that the high finish, hard sheet being supplied to English customers was entirely unsuited to American presses and press rooms, and steps were taken to soften the sheet and bring it in line with American and Canadian newsprint.

The change over from a hard to a relatively soft sheet has required several years, and is not complete yet. Certain changes were required in paper machine operation, but the most significant change was in groundwood quality brought about by revising grinding practice, changing from sandstones to artificial stones, and by changes in the screening of the groundwood. In this paper an attempt will be made to outline these changes in some detail and to relate groundwood quality with paper mill operating efficiency and paper quality.

Before going into detail regarding changes in the grinder room, and their effect on paper production or quality, it might be well to outline briefly the type of equipment in the mill under discussion. The paper mill at Grand Falls has seven newsprint machines, five of which are small, varying from 124 to 164 inches wide, and running at 870 feet per minute, and two 226-inch machines running at about 1300 feet per minute. These machines are all furnished from the same groundwood system, and the groundwood supplied must be suitable for both high- and low-speed machines. Groundwood is supplied from two grinder rooms both containing three-pocket grinders using 30-inch wood. The Grand Falls grinder room has 33 grinders, 24 of which are hydraulically driven, each line of six stones being directly coupled to a 4000-hp. turbine. The remaining nine stones are electrically driven from three motors, the stones being arranged 2, 3, and 4 stones to a line. The Bishop's Falls grinder room is located 11 miles from Grand Falls, and contains 15 stones, hydraulically driven. The Bishop's Falls groundwood is bullscreened, and put through Sherbrooke knotters with $^1/_4$-inch holes before being pumped to Grand Falls through a 20-inch pipeline. Consistency in this pipeline is 1.4%, and there are two pumping stations, one at Bishop's Falls and one half way between Bishop's Falls and Grand Falls. As it takes about 7 hours for pulp to reach Grand Falls after leaving Bishop's Falls, there is a large time lag between any change at Bishop's Falls grinders and the Grand Falls paper mill.

Screening of groundwood is carried out in Trimbey and Waterous screens, a two-stage system being used. Groundwood tailings are largely used locally for making mill wrapper, and only one refiner is in use handling about 5 tons a day.

One of the most serious complaints from American publishers regarding the Grand Falls sheet, was poor printability largely from lack of penetration of ink into the sheet due to the hard resistant surface. Extensive experimental work carried out in 1941 and 1942 showed quite conclusively that the poor printability resulted from two factors. The first was the actual physical hardness of the sheet, as shown by the low bulk and high smoothness, while the second was an ink-resisting quality of the paper which prevented ink penetration. At that time nothing could be done to soften the sheet, and a concerted effort was made to determine the cause and cure of the inability of the sheet to absorb ink.

Printing tests were carried out on a small hand proof-press printing solid black areas from a plate glass block and using weighed amounts of ink. Results were evaluated by visual examination, and by measuring per cent blackness, strike-through, and offset, using a Steele brightness tester. Test printing on

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a hand press, by this method, is very time consuming but gives results which are comparable in a general way to actual press room operation.

It was found that poor ink penetration was associated with a high degree of natural sizing in the sheet as shown by water penetration tests of around 2 seconds. Oddly enough no correlation could be found between ink penetration and castor oil absorption tests. It was also found that this paper, after aging for about 6 months, showed very high figures in water penetration tests, the degree of sizing being about ten times greater after aging than when first made. As the paper is often over a year old when used, it began to be seen why paper which seemed satisfactory when manufactured, should give such poor results in the press room.

During this phase of the investigation, the water penetration test, carried out by floating a 2- by 2-inch piece of paper on distilled water at 20° and noting time of penetration, was chiefly used as a measure of ink penetration. This test was found to correlate well with printing tests, and it can be carried out in a fraction of the time required for a printing test.

At this time machine changes were made, such as increased and decreased smoothness by changing calender nip pressures, use of top and bottom sweat driers, additional steam rolls at calender stack, dandy rolls off and on, and changing drier temperatures, none of which affected the water absorbency, which continued to be much poorer than in competitive newsprint.

Changes in furnish did not affect water absorbency until the amount of alum fed to the mixers was reduced which gave an immediate improvement in water absorbency. Data on this, first on newly made paper, and on sheets exposed to the atmosphere for 10 days showed as follows:

	Water penetration in seconds		
Age of paper, days	*Alum in sheet, lb. per ton*		
	13	*4*	*0*
1	1	1	1/4
10	13	7	1 1/2

The use of alum in the mill was discontinued and the water penetration test on the sheet dropped to around 1/4 second. The nonalum sheet exposed to atmospheric conditions for aging did not resist water nearly as much as the sheet containing alum. However, due to the color problem in this mill in the summer it is necessary to control pH in the system during the warmer months, and sulphuric acid has been used instead of alum for this purpose. Sulphuric acid has been found to have no effect on the water absorbency of the sheet. pH in the paper mill system is around 5.7 when no alum or acid is used, and in summer is kept around 5.2 with acid to prevent discoloration of groundwood from iron. About 2 pounds per ton sulphuric acid is required, and alum, when furnished, was used at around 10 pounds per ton to give pH values of 5.0 to 5.2.

Now it was found that while the Grand Falls sheet showed good water absorbency when fresh off the machine, and that it held this absorbency in storage if kept cool, it lost this absorbency on aging if the rolls were stored at moderately high temperatures, say over 70°F. Certain Canadian newsprints behaved the same way while others retained their good absorbency on aging, even at high temperatures. A number of samples from Canadian mills showing a wide range of water absorbencies when artificially aged at high temperature were tested in the laboratory to determine the reason for the difference in their properties on aging. The sheets showing slow absorbency rates were found to contain high resin contents, as shown below:

Mill	*Per cent resin in paper*	*Water absorbency in seconds All sheets aged 30 minutes at 140°C.*
A	0.34	0.25
B	0.38	0.25
C	0.43	19
A.N.D.	0.60	75
D	0.82	280+

These results were fairly conclusive and indicated that newsprint having a low resin content has the greatest rate of water absorbency. To confirm this samples of Anglo-Newfoundland paper had the resin partly or wholly extracted, and the sheets were then tested for water absorbency. In all cases it was found that sheets that had 0.3% resin, or less, remaining in them showed no increase in water absorbency time on aging.

A study of grinding conditions showed that the higher the grinding temperature the less resin was found in the groundwood. Resin extraction tests carried out on groundwoods, ground at various pit temperatures, gave the following results:

Grinder pit temperature, °F.	*Per cent resin extract*
95	0.68
130	0.61
150	0.54
190	0.36

It has been assumed that the lower resin content of the pulp at higher grinder temperatures is due to a greater degree of distillation of resins from the wood at these temperatures.

The relation between the resin content of groundwood and grinding temperature at Grand Falls is

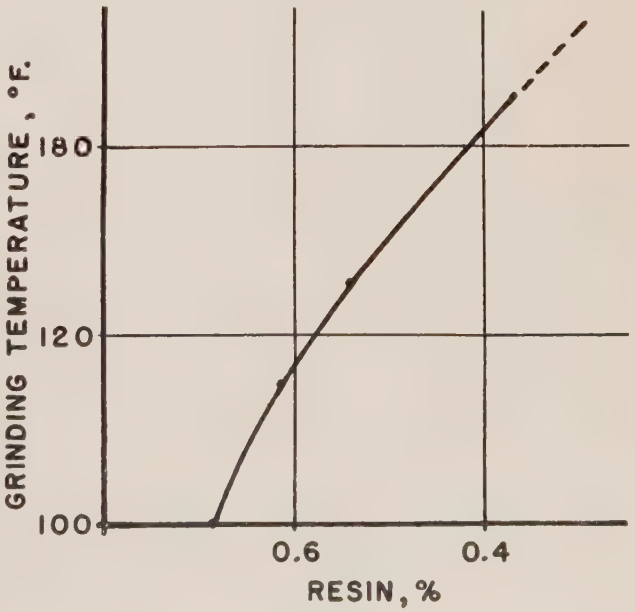

Fig. 1

shown graphically in Fig. 1. It should be mentioned here that the wood ground is a mixture of black spruce and balsam, about 50% of each, and no pine is used. It has been found that a resin content of 0.3% or less is required in the paper to insure no loss of water absorbency on aging, and no loss in printability. By extrapolating Fig. 1 it can be seen that this requires a grinder pit temperature of 200°F., which cannot be obtained in the hand-fed grinders at Grand Falls. Actually it has only been possible to bring the pit temperature at Grand Falls from around 155° to about 172° by increasing the pit consistency and raising the dilution and spray water temperature by closing the white water system. Higher temperatures have proved to be too hard on the grinder operators. Magazine grinders are being installed in this mill, and it is expected that better printability will result from the lower content of resin in the groundwood with higher grinding temperatures from the new stones. In the meantime every effort is being made to keep the grinder temperatures as high as possible. Reports from various press rooms indicate a great improvement in printability to date, and a further improvement is expected when the new grinders are installed.

GRINDER CHANGES

The second major change in the quality of Anglo-Newfoundland newsprint followed the installation of artificial stones replacing natural sandstones in both grinder rooms. With increasing percentages of artificial stones in use it became possible to soften the sheet by increasing the bulk and decreasing the smoothness. At the same time a general speedup in the paper mill led to increased productions. The general trends as regards quality of the sheet are shown in Fig. 2.

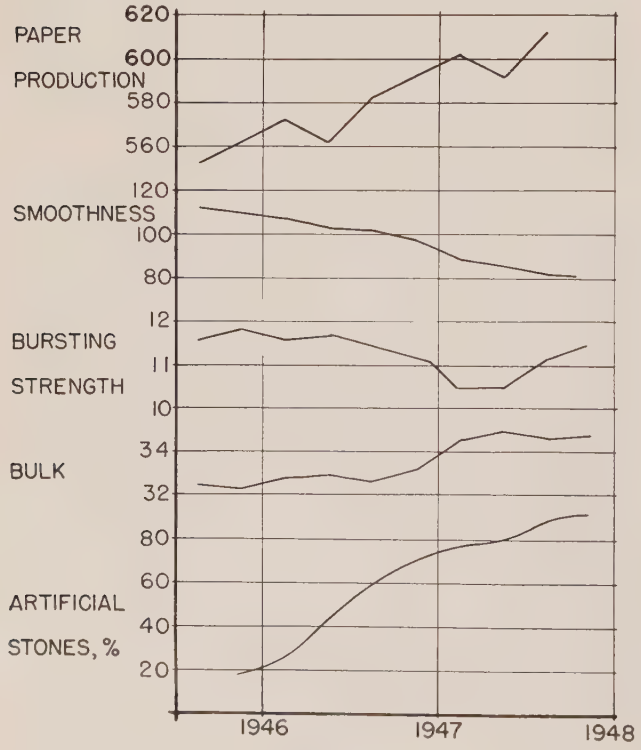

Fig. 2

It is interesting to note that these changes in sheet characteristics are reflected in reports of improved printability from customers.

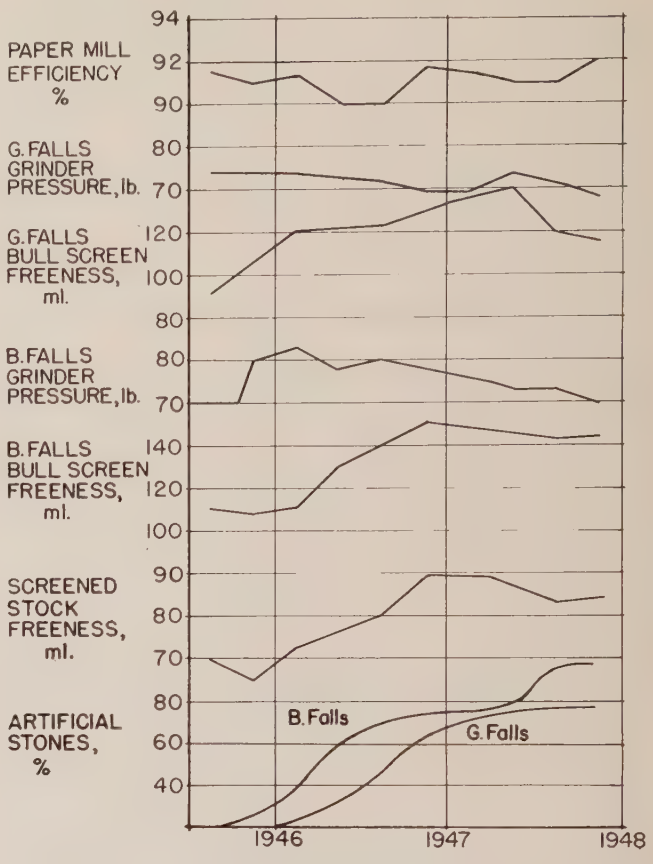

Fig. 3

Changes in freeness and grinding pressure against per cent artificial stones in use are shown in Fig. 3.

It should be mentioned at this point that it has been found possible to carry a much higher freeness using the artificial stones while still making an acceptable groundwood. It may be seen on Figs. 2 and 3 that with the exception of a period in the winter of 1946–47, paper mill efficiency increased slightly during the changes in the grinder rooms, and that paper production was increased materially over the same period.

BURRING

The general practice with sandstones was to sharpen a new stone with a coarse burr, usually an 8 by 3 or possibly a 10 by 3, and to continue using the coarse burr for some 60 days. New stones, 56-inch diameter, when sharpened with a fine burr ran dangerously hot. After about 2 months the burr was changed to a 10 by 3 which was used throughout the life of the stones. Sharpening interval was around 8 to 10 hours which led to a continuous variation in groundwood quality.

Artificial stones are trued up with a No. 12 or 14 diamond, and a new stone is sharpened with this burr for a couple of weeks, when the burr is changed to a 10 by $1^1/_2$ or 12 by $1^1/_2$. When the artificial stones were first installed the sharpening interval varied between 50 and 300 hours. A large number of tests of rates of production and pulp quality indicated that a sharpening interval of about 150 hours was most

satisfactory, and this interval has been followed since. At times the interval is changed for a few days to suit conditions, and it may vary from 130 to 200 hours. The longer sharpening interval with artificial stones undoubtedly yields a much more uniform groundwood.

Fiber classification tests were not carried out during the period of the change from natural to artificial stones as no equipment was available for this test. Visual examination of the stock on the blue glass and projection slides indicates that with the artificial stones a longer and finer fiber is produced than with sandstones. There is definitely less woody and short chunky fiber.

Typical screen classification tests on the present groundwood sampled at the bull screens are as follows:

	Grand Falls	*Bishop's Falls*
Retained 28-mesh	17.1	16.8
Retained 48-mesh	16.2	18.5
Retained 100-mesh	20.8	24.3
Retained 200-mesh	11.4	11.8
Passed 200-mesh	34.5	28.6

PRODUCTION

Production per stone has not changed in a significant manner with the change to artificial stones, or with the change in freeness. Tons per stone at Grand Falls are around 10.3 and at Bishop's Falls 13.3. Much higher productions per stone can be obtained by using coarser burrs, at present freeness values, but the pulp is unsatisfactory and causes trouble in the paper mill. The best paper mill operation has been obtained by carrying a higher freeness but using a finer burr, and keeping the tons per stone down.

To obtain the extra groundwood required by increased paper mill production, idle stones were put in operation, and a new line of four stones was installed in late 1947. Increased grinder capacity is being installed to take care of increased paper machine speeds without requiring any increase in production on existing stones.

It is not possible to accurately determine the horsepower per ton at Grand Falls. However, from several test runs made in 1947, the horsepower per ton appears to be about 65.

GRINDER SPEEDS

The most recently installed grinder line operates at 300 r.p.m. which is considerably faster than the older lines. With 54-inch diameter stones this gives a peripheral speed of 4240 feet per minute. Experience with this line has been very unsatisfactory and it appears that lower surface speeds give much better operation. The best burr on this high-speed line tried to date is a 14 by 3, but the pulp from any burr is poor being either very short or fine, or fairly long and woody. This trouble may possibly be due to the old hand-fed lathes on these grinders since it takes 40 to 50 seconds to run the burr across the stone when sharpening. It appears from experience in this mill that a lower stone surface speed and a higher grinding pressure are easier to handle and produce a better, more uniform groundwood. One of the most satisfactory lines at Grand Falls runs at 214 r.p.m., or 3140 feet per minute. This line operates with a grinding pressure of about 90 pounds, as compared to 70 pounds on the high-speed line, and consistently turns out a better grade of stock. The burst test of groundwood from the high-speed line is about 11.5, against 14.5 for the low-speed line, at similar freeness.

SCREENING

The layout consists of twelve Trimbey and four Waterous screens with 0.060-inch plate perforations for primary screening, and eight secondary Trimbey's having perforations of 0.120, 0.090, and 0.060 inch for rescreening the rejects from the primary screens. The ultimate rejects, amounting to 4% of the production, are run to one Haug refiner, to wet machines. Consistencies entering and accepted are 0.60% and 0.43%, respectively.

The Waterous screens which have been in operation since December, 1947, handling about 45% of all groundwood production, produce a cleaner and slower grade of stock than the Trimbey screens. Freeness of accepted stock from the Waterous screens is about 62 as compared to a freeness of around 78 from the Trimbey screens, both primary and secondary. Part of the improved cleanliness of the Waterous stock must be attributed to the fact that these screens run on all primary groundwood, while the Trimbeys are operating partially as secondary screens and are also handling stock from the refiner.

The accepted stock from the Waterous screens is normally mixed with accepted stock from the other screens and used on all machines, but this Waterous screened groundwood may be filtered separately and used only on one paper machine. This has been done when making rotogravure paper with a considerable improvement in quality as compared to paper made with the mixed groundwoods.

Screen classification tests, using a Bauer-McNett Classifier, of accepted stock from the various screens is as follows:

	Waterous screens (primary)	*Trimbey screens (primary)*	*Trimbey screens (secondary)*
Retained			
28-mesh	12.1	12.1	21.7
48-mesh	15.6	17.1	17.4
100-mesh	21.7	23.1	19.3
200-mesh	21.1	12.2	9.0
Passed 200-mesh	38.5	35.5	32.6

PAPER MACHINE CHANGES

Besides the changes in the grinder rooms, outlined above, certain alterations were made in the paper mill to help bring about the required change in sheet quality. The use of smoothing presses in the third press position, and of sweat driers, has been discontinued. Machine headbox temperatures have been increased from around 55 to 85° under winter conditions, and the present summer temperatures are around 100°F. The increase in headbox temperatures was brought about by the use of warm water supplied through recovery towers from waste drier heat, in Bird screen and pond showers, and by using white water in place of fresh water in the machine wire sprays. The white water system in the mill is still not completely closed, but efforts in this direction have raised all system temperatures some 10°. The closing of the white

water system and greater utilization of white water on the paper machines, with increase in temperature, appears to have given a definite improvement in paper quality and has allowed higher machine speeds at better efficiencies.

CONTROL OF GROUNDWOOD QUALITY

Up to the present time it is impossible to say definitely that any particular groundwood is good or bad from tests carried out on the groundwood. There is an indication that groundwood in certain freeness ranges, say around 110 at the bull screen with a burst of around 15 to 16, appears to tie in with good paper machine operation. This groundwood that gives good machine operation when examined visually by projecting it on a screen under a magnification of 35 times, has an entirely different appearance from "poor" groundwood, and appears to contain a higher percentage of long, fine fibers. This method of examination gives no quantitative results and is open to the criticism that it depends on personal judgment, but an impartial examination does appear to be of value in estimating the quality. Fiber classifications are now being carried out in conjunction with freeness, burst, and visual examination, but sufficient data have not been accumulated to determine if the fiber classification is of real value.

The best measure of groundwood quality in this mill is still the paper mill operating efficiency together with the burst test of newsprint. The machine speed must also be considered in attempting to evaluate groundwood quality since there is always a tendency to slow machines back at a time of poor operation such as when the groundwood is of low grade.

The most drastic changes in groundwood quality in this mill come from changes in wood; the density, age, and moisture content of the wood being important factors. Frozen wood, in winter, leads to an entirely different grade of stock. The grinding of satisfactory groundwood is certainly an art, and not a science, and the burring of a stone depends more on the skill of the stone sharpener than on anything that can be measured. While the freeness, strength, and appearance of the fiber serve as a guide, the final measure of the quality of groundwood is the way it runs on the paper machines. When changes are to be made in groundwood quality, they must still be made by means of the blue glass with the skill of the operator, a dominant factor. The day is still far off when a sample of groundwood can be sent to the laboratory, and a report indicating the efficiency to expect in the paper mill obtained.

At present in this mill groundwood control is based on bull screen freeness, tests being made hourly. Strength of the fiber classification and visual examination of the fibers are done daily. The standard figure for bull screen freeness is changed from time to time to suit the paper mill depending on paper mill operation and paper quality. It is realized that this method of control leaves much to be desired since serious defects in groundwood often are not detected until the stock is on the machines. However, until a better understanding is reached of all the factors involved in groundwood quality, it is probable that some such method must be followed.

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Selective Screening of Groundwood

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The manufacture of groundwood to be used in the production of paper and paperboard varying from facial, toilet, and wrapping tissue to heavyweight cylinder board specialties is described.

Grinding is a one-system operation for all grades of pulp. Quality and uniformity are based on the use of a group of relatively small-capacity grinders all standardized in stone character, type of burr, and temperature. Slight changes in pressure and a well-controlled burring cycle meet changes in wood character.

Sliver removal is followed by selective screening and subsequent blending of the primary grades produce a pulp of the required character.

The primary objective of this paper is to explain the method of producing groundwood pulp for purposes ranging from facial, toilet, and wrapping tissue to heavyweight board specialties. It is not a complete paper in itself from wood handling to instrumentation and technical and bacteriological controls.

The Oswego Falls Corporation has been making groundwood pulp for over 60 years. The initial plant was located where the power houses now stand, and was a water wheel installation typical of that day. The present plant, built some thirty years later a short distance from the old site, was equipped with eight 3-pocket grinders and the same grinders are in use today plus the usual replacements and repairs accompanying thirty years of continuous service. During this period the grinders have received many of the improvements that have come along both mechanically and technically including the artificial stone, temperature and pressure controls, motor recording ammeters, improved jigging equipment, and the numerous and ever-increasing advantages of technical control.

The present mill was designed and built for a capacity of about 60 tons, the approximate demand

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of the paper mill. The latter had a fourdrinier making newsprint, butchers, wallpaper, etc., and a cylinder machine making board specialties for the Sealright converting plant and other grades ranging from oyster pail to high caliper wood pulp board. Groundwood for the two machines was essentially different, especially for the extremes of the two machines. Operating a two-system groundwood mill to supply two different machines was not believed to be practical considering the small tonnage involved. There are many advantages inherent in a single system with screening to produce the two grades for the fourdrinier and for the cylinder machines.

Wet machines were installed to care for any overrun from full pulp mill production. These laps were stored to meet those periods of excessive paper mill demand or when water and power supply was low. By this action the advantage of all eight units of production was gained regardless of any inherent variables existing from stone face to human element, these differences being leveled out by their very number. Sharpening any stone could not affect pulp characteristics over a maximum of 12%. Screening could be altered or corrected and blending the fractions had great potentialities. Methods of grinding, uniformity in stone grit and face, technique in jigging, and in fact all human and mechanical rudiments of grinding could be better developed and controlled by a standardization in operation.

During the thirties the fourdrinier machine was discontinued and there was an excess of groundwood capacity. Tissue mills predominated in the immediate neighborhood, therefore, the pulp was screened a little finer, more wet machines were added, and the blending practices revamped for making tissue pulp. Making a satisfactory pulp for tissue and the other grades to follow was made much easier at the time because of the steady growth of the Sealright converting plant which took the full production of the cylinder machine. Making board specialties for the Sealright plant with the increasing requirements of cleanliness and slime control was quickly felt in the pulp mill. The improvements in quality, uniformity, strength, and cleanliness demanded in food packaging boards played no mean part in making a satisfactory tissue pulp and in the pulps that were added to the sales list in the years following.

Three distinct classes of pulps are now made, the first two being measured essentially in freeness with the third grade varying in character. The first grade is a fine pulp used extensively in various tissue grades such as facial, toilet, and wrapping. The second grade is an intermediate one generally used on board machines making tag, lined chip, folding box, wall and plaster board, single and double lined manila, patent coated, etc. It is also used on fourdriniers when a freer pulp is preferred. The third grade is pulp plus all the refined rejects of the fractionating screen system. No refined rejects are added to the first two grades as they are all used in the filler of the mill's board. The eight-cylinder machine with its many stock systems provides an ideal outlet for them. The machine also acts as a very realistic indicator as to quality.

This explains the history and general layout of the groundwood mill. Description of the equipment and a more detailed discussion of the operation follows.

GRINDERS

All eight grinders are the conventional three-pocket International built by Sandy Hill. The stones are installed in four parallel lines with two stones on each line, each line individually driven, which permits the four motors to be separated from the grinder room by a solid wall. They are all synchronous, 1000 hp. 2200 volts, 240 r.p.m. and with an ampere rating of about 207. The stones on each line are located so that the inside one is about 10 feet from the motor and there is about $9\,1/2$ feet between stones. The lines are on 20-foot centers. The grinder pockets are 15 inches wide and 18 inches deep. Six of the stones are 27 inches wide and two are 31 inches wide. This provides sufficient possibilities of handling any wood received or sawed long. The 31-inch stones are always on the inside of Nos. 2 and 3 lines where long wood from any point can be easily reached. The stones are all $54\,3/8$ inches in diameter when new and they are worn down to about 46 to 48 inches before replacement. The grinders are all equipped with the typical Meyer regulators, one handling each line so that the filling of one pocket distributes the pressure on the other five pockets and not just two. The grinder pits are 86 inches long and $42\,1/2$ inches wide with a 30° pitch on their outlet. All were lined with copper but have been replaced by stainless steel.

All stones are Norton's artificial with an average grit of 62. The outside and inside stones discharge into separate channels converging just ahead of the bull screen. The latter, without question, is a homemade affair consisting of two stainless perforated plates 5 feet 10 inches wide and 21 feet 4 inches long. The perforations are $3/8$ inch and are kept free with showers and eight 4-inch scrapers driven by a chain belt.

SCREENING

The selective screening system is composed of six centrifugal Improved Machine Company screens. All are identical with four 37-inch plates, capacity approximately 20 tons each, and are individually driven by motors from 40 to 50 hp. The motors are all 1800 r.p.m. with a reducing gear ratio $4\,5/6$ to 1 turning the screens about 380 r.p.m.

All the screens are in a straight line above the wet machines and fed by a common header from the bull screen pit. They have different size screen plates or combinations and a fairly extensive arrangement of pipes and valves plus mixing chambers called U drains provide the selective screening and blending with the necessary flexibility. The resultant pulp goes directly to the wet machines for sales or deckers for mill use.

There are five 96-inch wet machines with a capacity of about 10 to 12 tons. The two wet machines on the fine pulp are two cylinder units which helps to keep their tonnage equal with the other although they are lapping much slower pulp.

The two deckers for liner and filler stock are the conventional cylinder, couch, and doctor blade type. Of course, there are pumps, chests, and white water systems of the required capacity.

For refinement of rejects a Dilts 1800 refiner driven

by a 150-hp. motor is installed. The shell and plug are cast with $^5/_8$-inch bars. Its capacity is about 8 to 9 tons, and this is entirely adequate at maximum production figures. The rejects from the fine screens, at least the necessary proportion, are fed to the intermediate screens, and then reach the refiner. Once reaching the refiner system they are held until they have passed through the tailing screen and all this stock goes to cylinder machine filler stock. No initial rejects or refined rejects are returned to the fine screens.

OPERATION FEATURES

When the change from natural to artificial stones was made stones of a number 69 grit were used. They proved to be too fine making both the fine and coarse pulp too slow. A 55 grit was tried and was found to be about ideal, and had wood quality of prewar days continued, it would probably have been established as a standard. However, there appears little likelihood that pulp mills will ever return or be permitted to return to the selective wood cutting of those days. This situation has been met by reverting back to a 62 grit and this figure has been standardized to produce the ideal pulp for present purposes.

As to the type of burrs used and their use, the mill's experience is no doubt little different than that of anyone else. The range from diamond points to straight spirals has been explored over the years. For some time the mill definitely standardized on a number 12 spiral and $1^1/_4$-inch lead. Jigging equipment, as all realized, has as equal importance as the burr itself. Several years ago the latest Sandy Hill stone sharpening lathe was installed. It is operated by a two-direction hydraulic cylinder. The burr post is substantially built and supported with a heavy frame, and the whole lathe is of rigid character so that play or chatter is reduced to a minimum. In addition an indicating device which controls the setting of the tool provides means of duplicate dressing eliminating a great deal of the human element. As a standard practice all stones are dressed during the day shift providing positive opportunity of one person performing all jigging. In the burring cycle he arranges to sharpen soon enough to correct any tardy burring and late enough to offset any premature sharpening thus eliminating night jigging. Standardization on one person with a well-trained assistant, it is believed, offsets any variation that could occur during the evening shifts. There are, without question, exceptions to the rule especially when two stones must be dressed the same day, and this situation is met by flexible thinking and action by the supervision.

The stones are submerged in a pit $20^1/_4$ inches from the top of the pit dam, and the stone reaches within 4 inches of the bottom so that the stone is submerged in $16^1/_4$ inches of stock. The average pit consistency is about 8%, but there is no automatic control. A dulling stone with increased shower to prevent burning and the subsequent decrease production will lower consistency and the reverse will increase it. Ideal grinding appears to be from 155 to 165 degrees. Each grinder has a recording temperature gage located in full sight of the operator since control of temperature is essentially for maintaining freeness uniformity.

Grinding pressure is controlled, as before mentioned, by a Meyer regulator, but over-all pressure is hand-operated by controlling the setting of this automatic control. The pressure setting is actually determined by the recording ammeter on the motor which shows energy consumption. This gage is in full sight of the operator, but the tour bosses handle any change in water-pressure setting. With the pockets 15 inches wide and stones 27 inches in width, there is a grinding surface for the three pockets of $7^1/_2$ square feet. Grinding pressure has ranged from a low of 25 to a high of 42, but usually is run to a standard of about 34 pounds. This is governed by wood quality and strength desired. At this pressure the motor load is about 205 amperes. The kilowatt hour per cord on real dull stones will be about 1152 or 53.6 hp. days per ton. A sharp stone will drop to an extreme of 933 kw.hr. or 43.4 hp. days per ton. The average will run about 47.

Grinding with the above conditions given, at an average stone face and a pressure of 34 p.s.i., produces a fine pulp of from 23 to 25 bursting strength, and a tear of 48 to 52. The intermediate or board pulp for sale will run about 22 burst and a tear of 52 to 55. These are actual average figures since January of this year.

From the grinder pits the pulp goes to the bull screen and then directly by a common header pipe to the screens. All screens can receive the initial pulp, but needless to say, the majority will go to the fine screens which have 0.055-inch diameter holes in their plates. For a slightly higher freeness there may be a combination of 0.055 and one or more 0.065 to 0.070-inch screens in the second fine screen. The rejects from the fine screens go to the fine reject tank. These are pumped directly to the intermediate screens and mixed with whatever initial pulp is required. These rejects do not go to the next coarser screens, they go directly to the refiner system. The coarse screens usually are fed initial pulp, but with holes running from 0.075 to 0.090 inch, as any coarse pulp or even intermediate pulp must have some initial fines for complete satisfaction.

This system that has been described has vast flexibilities that only become fully appreciated and effective with the know how that comes from experience derived from working at it every day.

In summarizing, different grades of groundwood for various purposes are produced essentially by selective screening or a fractionating screen system. The uniformity of these pulps is basically dependent on the standardization of a group of three-pocket grinders producing a single groundwood system. In the production of about 90 tons a day not only quality but the constant uniformity of that quality in the different grades of pulp is desired. The type of grinder is not a matter of prejudice. It is believed that in making a relatively small tonnage of groundwood pulp there is soundness in the use of a group of small producing units to maintain uniformity with no one unit's production overproportioned to the total.

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The Physical Properties of Lignin

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RESEARCH on lignin is made difficult not only by its peculiar behavior in many chemical reactions but also by its undesirable physical properties. Because lignin is intimately mixed with carbohydrates in wood and other plant materials, it is almost impossible to study the physical properties of lignin as it occurs in nature. The only physical property of protolignin which has been determined is the ultraviolet absorption spectrum. This was done in Hägglund's laboratory by Lange who, using an ultraviolet microscope, found that lignin as it occurs in wood shows the same maximum at 2800 A in the absorption curve as do isolated lignin preparations. Because a special paper will be given on the ultraviolet absorption spectra of lignin, this physical property will not be discussed in the present paper.

All the physical properties reported in the literature have been studied on isolated lignins or lignin derivatives. Lignins, isolated from plant material after previous removal of accessory components by extraction of the carbohydrates with strong mineral acids or cuprammonium hydroxide, or by oxidation of the carbohydrates with periodic acid, are amorphous products. Although they still show the morphological structure of the plant fiber, they have been changed physically and perhaps also, to some extent, chemically. As was shown by Ritter, lignin carefully prepared from a small cube of wood still retains the shape of the cube and has the appearance of a piece of cellulose sponge, the hollow spaces being originally the seat of the carbohydrates. That these isolated lignins have been changed physically is shown by the fact that they are no longer thermoplastic as is the protolignin, that is, the lignin as it occurs in nature. They have no melting point. When heated, they decompose and finally char, leaving a highly surface-active charcoal. They are insoluble in all common organic solvents and in cold dilute alkali. Upon heating with 5 to 10% sodium hydroxide or sodium hydrosulphide solutions, for one to two hours at 160 to 170°, they are readily dissolved, giving clear dark brown solutions. From these solutions the lignins are precipitated again by carbon dioxide or by mineral acids, to give dark brown amorphous products which are now soluble in organic solvents and in cold dilute sodium hydroxide. Hydrochloric acid, cuoxam, and periodic acid lignins also can be rendered soluble by heating them with acetic acid or phenol in the presence of a small amount of hydrochloric acid or magnesium chloride as a catalyst, whereby acetic acid and phenol lignin derivatives are formed. Although these isolated acid lignins are at least partially soluble in bisulphite under the conditions of the sulphite cooking process, sulphuric acid lignin is insoluble in this reagent.

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Little is known about the stability of lignin. There is a general concept that, upon aging of the cut wood, the protolignin in it undergoes further condensation and polymerization. Evidence in favor of this claim is provided by the fact that freshly cut wood is somewhat easier to pulp by the bisulphite process than aged wood. Schwalbe found that spruce chips which had been aged for eight years could no longer be pulped. Whereas Schwalbe explained this change in pulping capacity as being the result of a physical alteration in the wood, Hägglund attributed it to a slow, still unknown, chemical change in the wood components.

It is known that the amount and properties of the extractives in wood change on aging, and the amount of native lignin which can be extracted by means of an indifferent solvent also changes with the aging of the cut wood. Furthermore, it is a matter of experience that isolated lignin preparations often change their physical properties, particularly their solubility and color, on aging. These changes are accelerated by the presence of traces of acids and by increased temperatures. In general, lignin preparations free of acid and stored in a dry place with exclusion of light can be kept for months without losing their solubility. This is also true for the salts of lignosulphonic acids. Free lignosulphonic acid is stable in an aqueous solution but on drying it readily becomes insoluble, particularly at elevated temperatures.

Isolated native spruce lignin and the organosolv lignin preparations are soluble in organic solvents and are recovered from these solutions by dropping them into solvents in which the lignins are insoluble—e.g., ether, benzene, or petroleum ether—upon which they separate as fine amorphous powders. Depending upon the fineness of the particles and the kind of derivative, they are more or less electrostatically charged, which often makes their handling extremely difficult. The acylated derivatives are often more highly charged than the unacylated compounds. Solutions of lignin and lignin derivatives in dioxane are clear without any Tyndall effect. Other lignins, such as alkali and thiolignin and lignothioglycolic acids, form colloidal solutions showing a strong Tyndall effect, but in dilute alkali they seem to give true solutions. Lignosulphonate solutions are largely colloidal.

All attempts to crystallize a soluble lignin have thus far been unsuccessful. Evaporation to dryness of lignin solutions in organic solvents leaves the lignin as a resin or a film with no sign of crystallization, although it was once claimed by Kuerschner that he had obtained crystalline nitrolignin derivatives. Like protolignin, isolated native spruce and other organosolv lignins are still thermoplastic. Because the melting points of these lignins are not sharp physical constants, they are of no value as a criterion for the purity or uniformity of lignin preparations. Native

spruce lignin, when suspended in water, softens at about 80 to 90°; when heated in a dry state, it softens at about 120° and slowly melts at about 140 to 150°. The melting point seems to change on aging. On cooling, the lignin hardens again to a brittle plastic mass which can be powdered readily between the fingers. On further heating, it decomposes and carbonizes, leaving a lignin coke. The melting points of some technical lignins which are recommended for use in the plastic industry have been reported to be between 140 and 190°.

The heat of combustion of ash-free hydrochloric acid spruce lignin was found by Rubner to be 6.277 kg.-cal. per gram.

The color of lignin and lignin derivatives depends upon the mode of their preparation. There is strong evidence that protolignin is almost as white as cellulose and that the colors of woods and other lignified materials are caused by extraneous coloring matters, rather than by lignin. This is supported by the fact that wood sections and even wood cubes can be bleached by a relatively very small amount of sodium peroxide to "a good white color" without affecting the amount of lignin, its methoxyl content, or its reactivity toward color reagents or bisulphite. Isolated native spruce lignin is light cream in color; the acid, cuoxam, and periodate lignins are light brown to dark brown depending upon the severity of the process of isolation. On methylation with diazomethane, protolignin and isolated native spruce lignin become almost white and the color changes to yellow or light brown on methylation with dimethyl sulphate. Other organosolv lignins become considerably lighter in color when treated with diazomethane. Thioglycolic acid and alkyl mercapto lignins are very light in color.

The density of lignin preparations has been determined by several investigators. Stamm at the Forest Products Laboratory found for a sulphuric acid lignin which was isolated from western yellow pine heartwood, 1.451 with water and 1.436 with benzene as displacement liquid by the pycnometer method. Similar values were found by Jodl for a cuoxam spruce lignin. For an organosolv lignin, such as dioxane lignin, Junker found 1.36. Because of the spongelike structure of lignin, its apparent specific gravity is much lower. Saechtling and Zocher determined the volume or bulk weight of cuoxam spruce lignin to be 0.345 to 0.352.

Viscosity determinations have often been used for the characterization of high molecular compounds and have also been applied to lignin. Wedekind and Katz determined the relative viscosity of some phenol spruce lignin derivates in acetone and chloroform and found that it increased approximately proportionally to the concentration. Staudinger and co-workers studied the specific viscosity of formic acid spruce lignin isolated under very mild conditions and separated by fractional precipitation into three fractions. They found that the viscosity was the same for all fractions, indicating that no separation into fractions of different molecular weights had occurred. From the low values found, they concluded that the organosolv lignins cannot consist of long chain molecules. The specific viscosity corresponds to about that of a cellopentaose acetate of a molecular weight of 1542. If lignin consists of a chain molecule, the chain cannot be very long and must be built up of about 5 to 6 coniferyl alcohol groups. According to Staudinger, the lignin molecule does not possess a threadlike form but is approximately spherical in shape. Loughborough and Stamm, Junker, and Erbring and Peter reached similar conclusions.

The knowledge of the molecular weight of lignin is of great importance for the elucidation of its structure and, consequently, many attempts have been made to determine it. When we speak of lignin, we do not mean a definite uniform compound such as morphine or quinine; the term lignin is a collective term for a group of highly polymerized compounds of very similar chemical properties, in the same sense that cellulose is a collective term for a series of carbohydrates of the same structure, but of different molecular sizes. The term lignin is even somewhat broader, because it comprises the lignins of widely different plant materials and we know definitely that lignins from deciduous woods differ in their chemical composition from those from coniferous woods. It is not surprising, therefore, that the molecular weights reported in the literature vary widely. Molecular weight determinations have been carried out by every known chemical and physical method, but thus far none has given a satisfactory result. By the introduction or the cleavage of known groups by means of reactions which take place quantitatively, the lowest possible unit weight for the reaction used can be determined with fairly good accuracy as long as the analytical differences are large enough to allow any conclusions to be drawn as to the exact number of atoms or groups introduced or removed. Thus, by the introduction of one methoxyl group by means of diazomethane, the molecular weight of the building unit of native spruce lignin was found to be 840; and that of methanol spruce lignin 861. For an alkali flax lignin Beckmann and Liesche found 840, calculated from the acyl content of various acylated derivatives. Sarkar, on the basis of the amount of formaldehyde split off from an alkali jute lignin, found 830 and Kuerschner, on the basis of the nitrogen content, found 422 for spruce nitrolignin.

Of the physical methods for the determination of the molecular weight of lignin preparations, the cryoscopic, ebullioscopic, diffusion, and osmotic pressure methods and the ultracentrifuge have been used. The results vary between 250 and 11,000. The values vary not only with the type of lignin derivative, but also with the same lignin when different methods are used. Thus, for instance, Stamm and Loughborough found for various maple lignin preparations around 4000 by the ebullioscopic and osmotic pressure methods, and around 10,000 for the same lignin by the diffusion method. The higher values were explained as being due to the formation of polydispersed solutions, or to a departure of the molecule from a spherical shape.

Gralén, in Hägglund's laboratory, determined the molecular weight of a number of thioglycolic acid lignins from spruce and other plant materials by sedimentation measurements at different concentrations, using the Svedberg ultracentrifuge. An average molecular weight of 7000 was found for thioglycolic acid spruce lignin. Based on a lignin building stone of $C_9H_9O_3(OCH_3)$, a degree of polymerization of about

36 was calculated. From the sedimentation and diffusion data, a shape factor of about 5 was determined. When the wood was pretreated with dilute alkali or acid, the thioglycolic acid lignin had a degree of polymerization of 146, indicating that condensation or polymerization had taken place during the pretreatment.

The molecular weight of lignosulphonic acids should be discussed briefly. The unit weight, when based on one sulphonic acid group, depends, of course, upon the sulphur content of the acid. The sulphur content, in turn, depends on the mode of preparation. Under carefully controlled and mild conditions a lignosulphonic acid can be obtained with a sulphur content of about 3.5%; this seems to be the minimum sulphur content required to render the lignin soluble. On the basis of this sulphur content, a molecular weight of 954 was calculated by King for a lignosulphonic acid building unit. Lignosulphonic acids with a higher sulphur content (such as 5 to 7%) have, of course, a smaller unit weight. It has been known for a long time that the lignosulphonic acids in sulphite waste liquor can be separated, by fractional precipitation with various bases or electrolytes, into fractions of different sulphur contents and different molecular weights. The lower the sulphur content, the more readily is the lignosulphonic acid precipitated. This does not necessarily mean that the lignosulphonic acid with the lowest sulphur content has the highest molecular weight. It has the highest *unit* weight, although the number of units which make up the lignosulphonic acid molecule may be smaller than that of a lignosulphonic acid with a higher sulphur content and consisting of a larger number of building units. No conclusions can be drawn from the molecular weights of the lignosulphonic acids in a waste liquor as to the molecular weight of the protolignin, because degradation or condensation of the lignin may have taken place. In general, however, it can be said that lignosulphonic acids of a low molecular weight have a relatively high sulphur content. That lignosulphonic acid in sulphite waste liquor is a mixture of acids of various molecular sizes was clearly shown by Erdtman and by Schwabe and Hasner. The latter separated a purified ammonium lignosulphonate of an average molecular weight of 1865 by fractional dialysis into four fractions and obtained 34.9% of a lignosulphonic acid with a molecular weight of 325, 15.9% with 480, 33.9% with 1745, and 15.9% with 20,500.

The dimensions of large molecules can be determined from the measurements of the area covered by a monomolecular layer when spread on a liquid in which it is insoluble. Such spreading experiments were first carried out by Wedekind and Katz who found a layer thickness of about 10 A for phenol spruce lignin. Freudenberg found for a sodium lignoazobenzenesulphonate a layer thickness of 20 A, whereas Loughborough and Stamm found a film thickness of 16 A for methanol maple lignin.

Another physical property which is of importance in lignin chemistry is its sorption capacity. Here one must distinguish between chemical combination and physical sorption. Because of its permutoid character, lignin is capable of combining with bases and acids. This property is encountered even in the preparation of lignin by mineral acids. When wood is treated with supersaturated hydrochloric acid, lignin separates as a dark violet brown, almost black, lignin-hydrochloric acid addition product which, on treatment with water, loses the hydrochloric acid with a simultaneous change in color to light brown. A similar observation is made in the preparation of sulphuric acid lignin.

The first adsorption experiments with lignin were carried out by Wedekind and Garre who found that hydrochloric acid beech and oak lignins take up hydrochloric acid and alkali, the values forming a linear curve. Whereas the acid could be washed out almost completely with water, the alkali was irreversibly combined, indicating a chemical combination of the base with the lignin. A straight line adsorption curve was also obtained with sulphurous acid, of which a part was irreversibly combined with the lignin. The adsorption of iodine also followed a straight line and, because only a part of the iodine could be removed by sodium thiosulphate and no hydriodic acid was formed, the iodine must have reacted with the lignin through addition. The fact that basic dyes are firmly adsorbed by lignin and acid dyes are not taken up at all indicates that lignin possesses a negative charge. This is further proved by cataphoretic experiments with alkali lignin sols, whereby the lignin migrates to the anode. Such sols are readily coagulated by small amounts of electrolytes, indicating a very low hydration of the lignin particles. Positively charged sols, such as aluminum hydroxide sol, precipitate the lignin sol. Ammonia is readily adsorbed by acid lignins and lignin gels, the amount of ammonia taken up depending upon the gas pressure. On dialysis it is completely split off again. Neutral salts are not adsorbed by lignin. Water vapor isotherms of cuoxam spruce lignin were determined by Saechtling and Zocher and by Jodl. The latter distinguishes three types of reactions by which water may be taken up by lignin. About 2% of the water is firmly combined, probably in the form of hydrate water, and can be removed only in a high vacuum at 130°. Another part, the so-called lyosorption water (amounting to 2 to 6%), is adsorbed on the surface of the lignin in the form of lyospheres; finally, large amounts of water (6 to 25%) are taken up through the polycapillary system of the lignin, the surface of the molecules is freely exposed, A in diameter, with the smaller types predominating. In addition to these capillaries, acid and cuoxam lignins contain a large number of micropores of approximately 2000 A in diameter which, in wood, are filled by cellulose. Assuming that the lyosorption water covers the lignin in a monomolecular layer with a thickness of 2.5–3 A, Jodl calculated a surface area of 180 square meters for one gram of cuoxam spruce lignin. The same value was calculated from the measurements of the crystallite cylinder areas found by x rays. This large surface area indicates that, in lignin, the surface of the molecules is freely exposed, thus accounting for the fact that the solid lignin behaves in reactions like a compound in solution. In other words, it reacts throughout the molecule in the same way as does the cellulose fiber. The fact that lignin adsorbs organic solvents, such as methanol and

acetone, with considerable swelling, more readily than water indicates that lignin is an organophil compound.

As is so often the case in lignin research, the results of x ray investigations of lignin preparations are contradictory. While Wedekind and Katz and several other investigators could not find x ray diagrams indicating a crystalline nature for organosolv lignins, Harris and co-worker obtained with a sulphuric acid aspen lignin and some organosolv maple lignins, x ray patterns typical for the crystal lattice of organic substances with a high molecular weight. Jodl, working with a cuoxam spruce lignin, arrived at similar results and claimed that lignin is submicrocrystalline.

On removal of the carbohydrates from wood by means of strong mineral acids, about 72% of the wood substance is removed. In spite of this loss, there remains a coherent lignin framework which shows the hollow spaces originally filled with carbohydrates. The presence of these cavities is shown by the behavior of acid and cuoxam lignins under the polarization microscope. The double refraction, which Fuchs believed he had discovered, was found by Freudenberg and co-workers to be a form of double refraction, caused by the hollow spaces left on removal of the cellulose. By using liquids of increasing refractive indexes, the double refraction gradually disappeared until a liquid of a refractive index of 1.61 was used. In the high refractive index of 1.6 for lignin, Freudenberg saw further proof for the aromatic nature of lignin.

Although most of the compounds synthesized in plants are optically active and all formulas thus far suggested for spruce lignin contain asymmetric carbon atoms, the question of whether or not lignin is optically active is still open to discussion. With the exception of Wedekind and Garre, who found a considerable specific dextro rotation for an alkali lignin, no other investigators, using lignin preparations isolated under the mildest possible conditions, could detect any optical activity. Isolated native spruce lignin also showed no sign of optical rotation, as far as the dark color of the solution permitted observation.

Another physical property, not of lignin in general, but of lignosulphonic acid must be mentioned. Kirmreuther and co-workers found that unbleached sulphite pulp, when exposed to ultraviolet light, showed an intense violet fluorescence. Because neither cellulose nor resins gave this fluorescence, they concluded that it was caused by the lignin residue in the pulp. This phenomenon was further studied by Hägglund, who observed two different types of fluorescence, a luminous and a nonluminous. The former was less stable and was destroyed on treatment with alkali and reacidification, whereas the latter turned a bright yellow green and was restored upon acidification. According to Hägglund, the fluorescence is caused by the solid lignosulphonic acid in the unbleached pulp. Isolated lignosuphonic acid also shows a strong deep violet fluorescence. Protolignin and other isolated lignin preparations show only a weak bluish fluorescense, similar to that of bleached cellulose.

There remain two important physical properties which should be discussed—i.e., the ultraviolet and infrared absorptions spectra of lignin. Because we have an expert in these fields, namely Mrs. Aulin-Erdtman who is a specialist in the ultraviolet absorption of lignin and related compounds, and Edward J. Jones, who opened up the field of study of the infrared absorption of lignin, the author will leave the discussion of these subjects to them.

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Ultraviolet Spectroscopy of Lignin and Lignin Derivatives

GUNHILD AULIN-ERDTMAN

The first investigations in the field of the ultraviolet absorption spectroscopy of lignin were carried out about 20 years ago. At that time there was no definite conception of what contribution this method could be expected to make to the chemistry of lignin. With our present experience, we are able to see more clearly the possibilities and the limits of this kind of research in the lignin field.

In lignin work, as well as in ultraviolet spectroscopy in general, a close integration with purely chemical work is essential for progress. The physical theory of absorption spectra of molecules is an extremely complicated one. In fact, it is so incomplete that it is impossible to deduce mathematically the formula of even a comparatively simple organic molecule from its ultraviolet absorption spectrum. All conclusions of this kind are based on our knowledge of the spectra of similar compounds. Such conclusions may be easy to draw when one is dealing with a pure compound of a structural type that has characteristic and well-known spectra. However, in the case of lignin, conditions are not as simple because of the special properties of the material.

This review will deal with softwood lignin only. The main obstacle in lignin spectroscopy, as well as in lignin chemistry in general, is the impossibility of dissolving at least the main part of the very reactive material without simultaneously changing its structure in some unknown way. Every conceivable method for accomplishing the dissolution of the lignin in an unchanged state has been tried so that the chances for success are certainly minute. One must draw the conclusion that at least the bulk of the material has

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a very high molecular weight or is chemically combined with some other constituents of the wood.

Another difficulty arises from the polydispersity of the soluble lignin derivatives. These preparations all consist of a mixture of molecules of different size, most probably polymers of structural units of a few similar types. Unless one is able to remove the smaller polymers from the material, the influence of the end groupings on the spectrum will be considerable.

Furthermore, it is necessary to take into consideration the possible existence of different building stones in the lignin. Regarding the softwoods, there is still no definite evidence against the view that the lignin is built up mainly from identical building stones, although these may be combined in different ways. In 1933, Hillmer (*1*) claimed to have proved the identity of the building stones by his spectrographic investigations. He expressed this opinion in the following words: "Ein grosses Molekül nämlich, dass aus verschiedenartigen aromatischen Einzelelementen zusammengesetzt wäre, müsste, sofern diese kein konjugiertes System bilden, auf Grund der optischen Additionsgesetze eine sehr verwaschene Absorptionskurve aufweisen." His conclusion regarding the identity of the building stones of sprucewood lignin must still be regarded as mainly correct, though it was rather bold at the time since his spectra were after all rather "verwaschen"! However, even with our present day absorption curves of the best lignin preparations, we cannot avoid assuming the existence, at least in the lignin derivatives, of a minor amount of dissimilar structural units.

Most of the reactions that occur in the lignin molecule during its isolation from the wood presumably take place in the nonaromatic parts of the molecule. Hence, one would not expect these different lignin derivatives—such as acetic acid lignin, lignosulphonic acid, methanol lignin, and the like—to have very different spectra; much less so, different preparations of the same kind. However, if lignin is isolated from wood by means of the different methods described in the literature and the absorption spectra of the different preparations are determined, one will find great differences between the curves, even if the mildest possible isolation conditions are used in each case. Figure 1 is an example of such a group of absorption spectra and gives a good illustration as to what different materials can be called lignin. Side by side with the ordinary analytical methods, the spectroscopic method should be used much more than is actually the case for characterizing different lignin preparations and selecting the ones suitable for further investigation.

The lignin preparations, the spectra of which are shown in Fig. 1, were all freshly prepared except the "native lignin," which was kindly supplied by Brauns and which, at the time of this investigation, was about two years old. The ϵ-values of the curves are based on the equivalent weight of each preparation, calculated according to the methoxyl content. (ϵ, therefore, is not a real molar constant in this case.) The methoxyl content has turned out to be a rather good index of the content of benzene nuclei in the various lignin preparations, the value of ϵ in the 280 mmu maximum being fairly constant. In some cases, however, there is a marked deviation from the normal state, the maximum being too high or too low. The preparations with the high maxima have been prepared by methods involving the use of strong mineral acids or other rather drastic conditions, in which some methoxyl may have been split off. Another explanation may be that the preparations contain some reaction products derived from carbohydrates and formed during the isolation process, which are difficult to separate from the lignin material and absorb light of the same wavelength. The low value of the maximum in the case of ethanol lignin is due to the ethoxyl groups being split off with the methoxyls in the analysis.

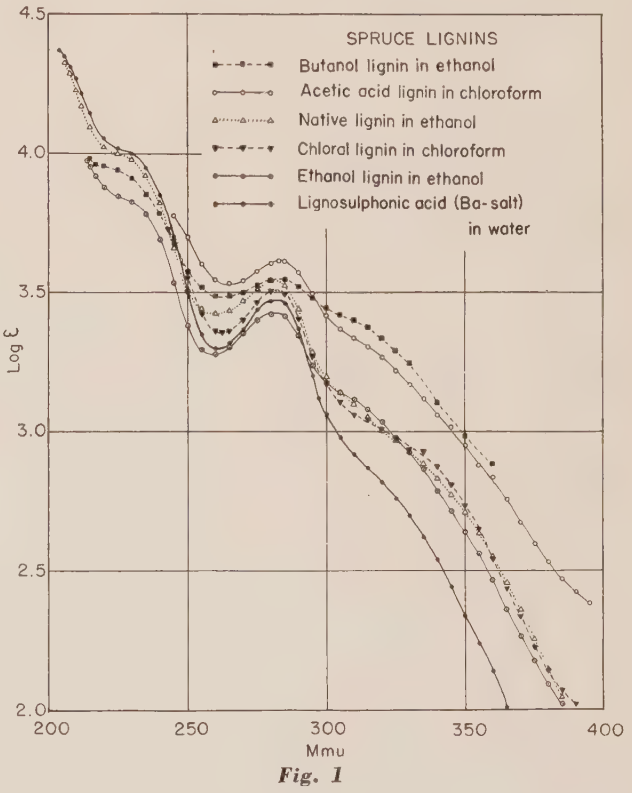

Fig. 1

Methods of preparation: Butanol lignin, H. Y. Charbonnier, *Paper Trade J.* 114, No. 11: 33 (1942); Acetic acid lignin, H. Pauly, *Ber.* 76: 868 (1943); Native lignin, F. Brauns, *J. Am. Chem. Soc.* 61: 2126 (1939); Chloral lignin, A. Ogait, *Cellulosechemie* 22: 17 (1944); Ethanol lignin, B. Holmberg and S. Runius, *Svensk Kem. Tidskr.* 37: 195 (1925) (yet 6 hours and 0.5 *N* hydrochloric acid); lignosulphonic acid, see text.

Figure 1 serves as a warning for increased caution in choosing preparations for the investigation of the properties and structure of true lignin. Now the question is how to choose in order to find the preparations with the fewest and least severe alterations from the original lignin structure.

Some guidance is given by the color of the preparations. Since the lignin in the wood is very light or colorless, dark preparations are bound to have undergone changes, these changes being more severe the darker the color of the material. The ultraviolet absorption curves of the dark lignin preparations are always flat, whereas the light ones show steep curves

with sharper maxima and minima, their curves being more similar to those of pure aromatic substances. In this respect lignosulphonic acids are outstanding among the lignin preparations, a fact which has been shown by Hägglund and Klingstedt (*2, 3*) and pointed out by Stamm, Semb, and Harris (*4*).

The lignosulphonic acid, the absorption curve of which is shown in Fig. 1, is lighter and has a steeper ultraviolet spectrum than most other lignosulphonic acid preparations investigated. It was prepared according to Kullgren (*5*) from sprucewood by using a

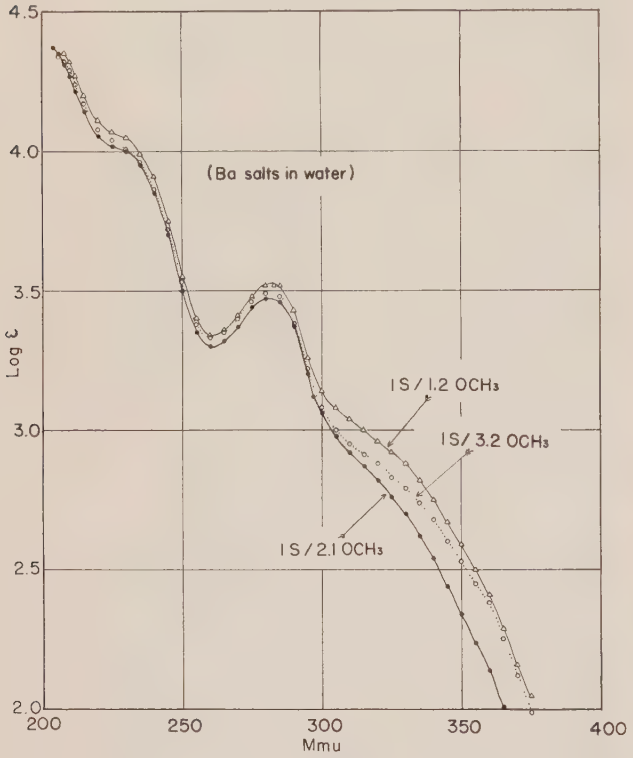

Fig. 2. Effect of renewed sulphonation of lignosulphonic acid from low sulphonated wood

sulphite cooking acid of pH 5 under mild conditions so that most of the lignin remained undissolved. The waste liquor was discarded, and the solid wood material treated with 0.01 *N* hydrochloric acid in order to substitute hydrogen ions for the calcium ions. The free lignosulphonic acid obtained was then dissolved by treatment of the material with hot water (80 to 90°C.), purified by precipitation with an organic base, and treated again with sulphite cooking acid until 1 sulphur atom per 2.1 methoxyls had been introduced.

Figure 2 lends additional support to the assumption that this preparation is of true lignin character. In this diagram the same spectrum is shown together with that of the original lignosulphonic acid, from which the other preparation was obtained by further sulphonation. The third spectrum on the diagram is that of another lignosulphonic acid preparation obtained from the same starting material by a still stronger additional sulphonation. A comparison of the spectra shows that no very great change of the absorption has resulted from the second sulphonation (*6*) although the sulphur content has increased to almost three times the original value. Therefore, at least the secondary sulphonation probably takes place in the nonaromatic parts of the molecules, and we have no reason to assume that that is not also the case in the primary sulphonation.

What has been accomplished thus far regarding the elucidation of the structure of lignin by means of spectroscopic methods? This question is rather hard to answer, because of the developing correlation between this method and purely chemical ones. However, the author will point out some cases in which spectroscopic data have been of great help or even laid the basis for establishing the conclusions made.

In the first place the author would like to mention the definite proof of the aromatic nature of lignin in wood. No chemical investigation has been so conclusive in establishing this fact as have Lange's (*7*) ultraviolet absorption measurements on the native wood.

Even up to the present, some wood chemists have doubted the existence of an aromatic lignin in the wood. Instead, they have held that the aromatic lignin is a secondary product, arising as a reaction product from some nonaromatic lignin precursor in the wood. Now it so happens that carbohydrates do not absorb ultraviolet light in the easily accessible region, and aromatic accessory constituents of the wood can be removed easily by extraction with organic solvents. Hence, if the remaining wood shows an

Fig. 3

absorption maximum of about 280 mmu, such absorption must be due to lignin and will prove the aromatic character of lignin in wood.

The technique which Lange used was developed by Caspersson (*8*) for other purposes and consisted of ultraviolet microscopy of thin wood sections in an apparatus permitting the use of ultraviolet light of different wavelengths, a precise, controlled focusing of the specimen, and the measuring of the intensity of absorption by the use of a multistep rotating sector.

Figure 3 shows one of Lange's photomicrographs of spruce wood at 280 mmu. The strong absorption of the light in some parts of the tissue shows beyond doubt the existence of an aromatic compound in the extracted wood. By measuring the intensity of ab-

sorption at a certain point in the wood section at different wavelengths, Lange constructed the absorption curve for the solid lignin, which is shown on Fig. 4 (*7*) together with the spectra of some model substances, also determined on the solid material. The similarity between the lignin curve and that of dihydrodehydrodiisoeugenol is evident and indicates a structural similarity between the two. However, this similarity between the spectra must not be over emphasized because of our very limited knowledge of the spectra of solid substances. Several substances may exist which will fit just as well as lignin models. A large amount of work remains to be done in this field before one can draw definite conclusions about the structural details from the experimental data.

Lange (*9*) has been able to estimate roughly the proportion of lignin in different parts of the cells by assuming the same absorption power for lignin as for dihydrodehydrodiisoeugenol at 280 mmu. For the compound middle lamella he found about 70%, this proportion gradually decreasing toward the lumen of the cell. The distribution of the lignin is shown roughly in Fig. 5. By integrating over the complete volume of the cell he calculated the over-all lignin

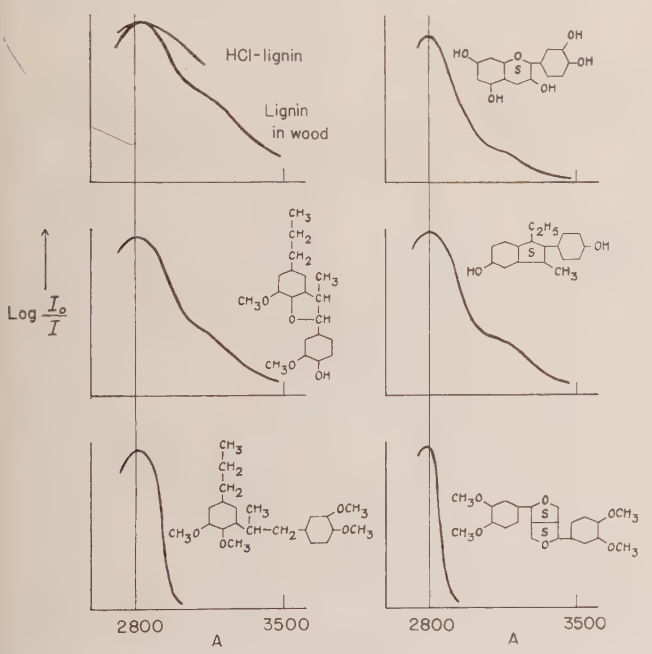

Fig. 4

content in the wood. The figure he found for spruce was 27 to 30%, which is certainly more exact than could be expected from such as estimation.

These investigations have been carried on in different directions. By studying the dichroism, Lange (*9, 10*) has found that the lignin molecules are oriented in the wood and that this orientation gradually disappears during the sulphite cooking process. He has also been able to show that the sulphite cooking liquor starts its attack in the middle lamella and that the absorption curve of the lignin is only slightly altered during the sulphonation (*9, 10*).

By Lange's work the old argument about the aromatic structure of lignin in wood has been settled definitely. This structural type for lignin has for a long time been pointed to by ultraviolet spectroscopists, their assumption being based on spectroscopic evidence from soluble lignin preparations. The benzenoid type of these preparations was proved by the pioneer work of Herzog and Hillmer (*11*) and Hägglund and Klingstedt (*2, 3*). Only the step from these to the original lignin needed confirmation.

Spectra of solid substances still being very incompletely known, we have to consider work on soluble lignin derivatives for more detailed information regarding the structure of lignin. Herzog, Hillmer, and

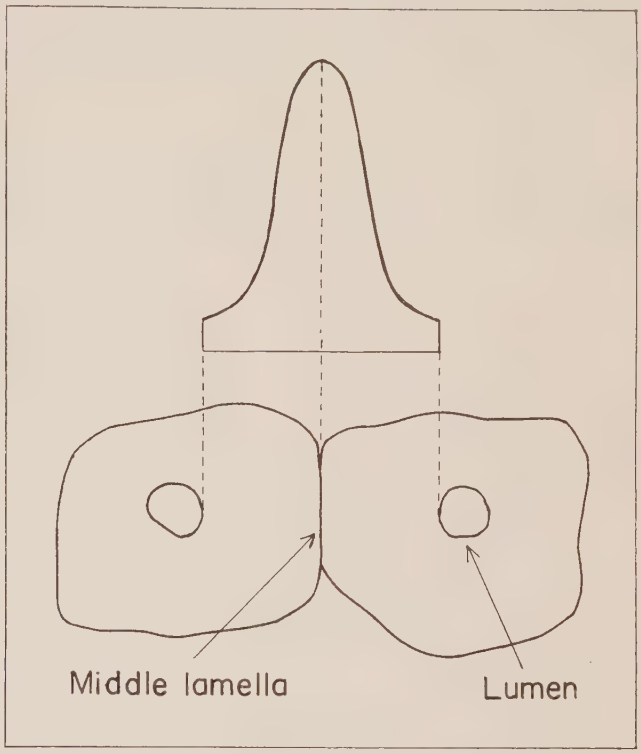

Fig. 5. Distribution of lignin

their co-workers did not stop at proving the existence of aromatic nuclei in the lignin derivatives. In order to find out how these benzene rings were substituted, they carried out systematic absorption measurements on a large number of benzene derivatives with substituents in different positions. This work enabled them to state (*12*) that spruce lignin is a derivative of a divalent phenol, namely pyrocatechol, a result agreeing very well with the evidence obtained in pure chemical research. In later model investigations carried out by Hibbert and others, this work has been confirmed.

Some years ago an attempt was made (*13*) to further characterize the lignin molecule in connection with Freudenberg's well-known model structural formula for softwood lignin. Figure 6 shows the structural relationship between three molecules, the right one being Freudenberg's macromolecule. The structure of the monomer is changed stepwise through the dimeric intermediate to the polymer. It should be noticed that the first step involves exactly as great a change as the last one, half of the linkages being formed in the first step and the other half in the last one. A corresponding stepwise change in the absorp-

tion spectra is to be expected between the two low molecular model substances and lignin, if the macrostructure is a good formula for lignin. In Fig. 7 the values of ϵ are calculated per phenylpropane unit (or rather per molecule, per half molecule, and per methoxyl, respectively) in order to facilitate the comparison. The agreement with the theory is fairly good as far as wavelengths below 300 mmu are concerned, indicating the possibility of a Freudenberg-type formula for part of the lignin. However, it will probably not be possible to distinguish between, for example, 5- and 6-membered oxygen rings by this method as long as we do not know the exact spectrum of lignin. The author also wants to point out that the inflexion in the lignin preparation curve at about 320 mmu does not correspond to any similar feature in the spectra of the model substances.

Figure 7 can also be used for discussing Freudenberg's (*14*) assumption that the sulphonation of lignin consists in the opening up of furan or pyran rings. If that hypothesis were correct, the dimer containing

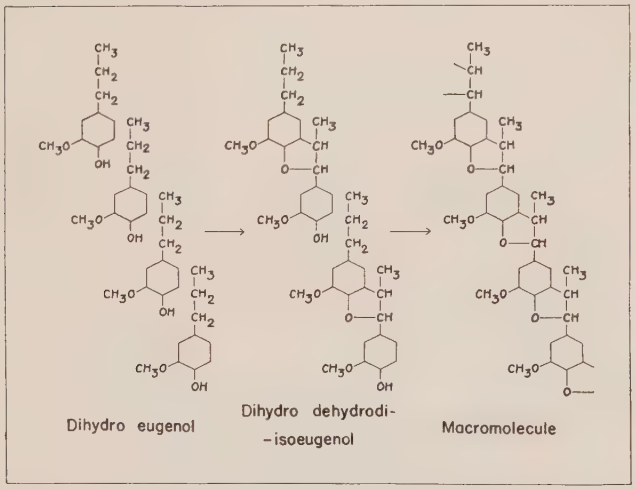

Fig. 6

no oxygen ring should be a better intermediate than dihydrodehydrodiisoeugenol, which is not the case. The difference between the spectra of the two dimers discussed being rather great, we would also expect a significant difference—for example, in the intensity of the maximum—between the spectra of lignosulphonic acids of different degrees of sulphonation, if an oxygen ring were actually split for each sulphonic acid group introduced. As was shown by Erdtman (*6*), and Lange (*9, 10*), however, no such difference is found (see also Fig. 2).

All the lignin derivatives thus far investigated differ markedly from simple aromatic substances in showing a gradually diminishing absorption intensity above 280 mmu, instead of the sharp limit of absorption power toward longer wavelengths which is intrinsic for the latter. However, this bump (see Fig. 1) in the lignin derivative spectra is less marked, the milder the conditions employed in their preparation. Hence, one would be tempted to believe that it is derived from structural details not existing in the protolignin but resulting from some reactions during the isolation process. Of course, that is only a guess, as we do not know the spectrum of protolignin in solution. Unfortunately, it is not yet possible to draw definite conclusions from the small wave existing in the spectrum of solid lignin (Fig. 4).

An example of the influence of drastic isolation conditions is shown in Fig. 8, where the spectrum of the

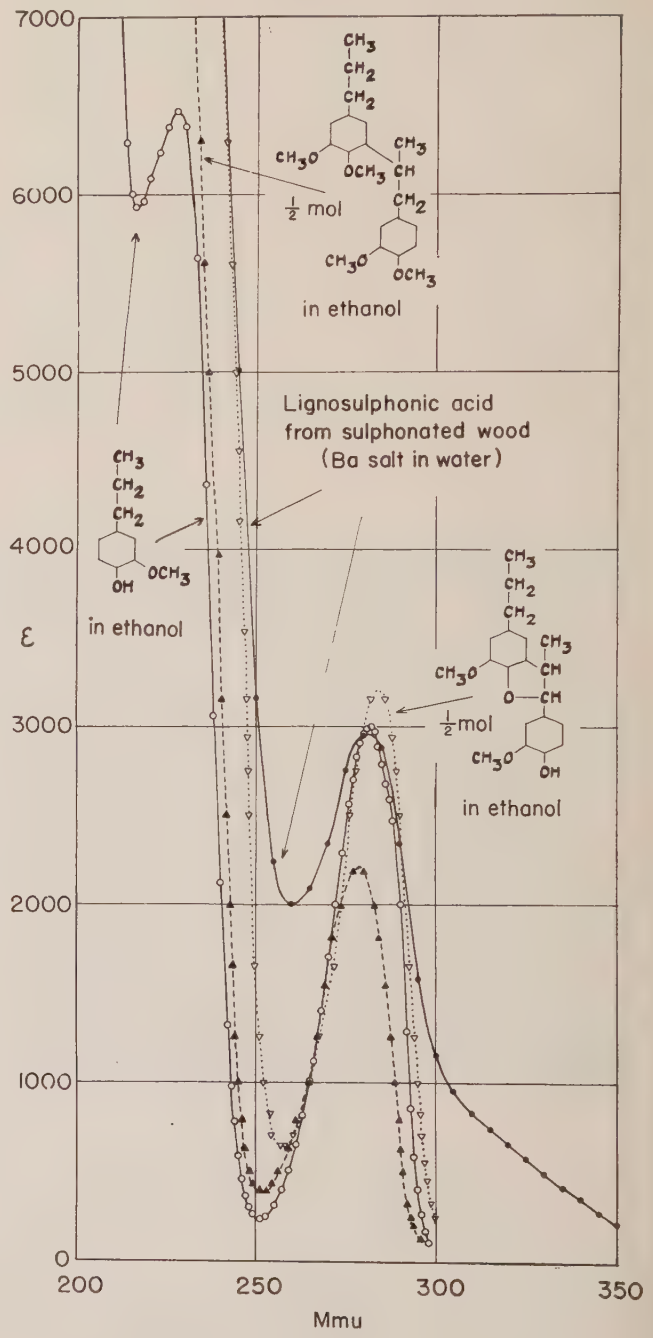

Fig. 7

reference lignosulphonic acid can be compared with that of a purified specimen of lignosulphonic acid from a technical rayon pulp cooking liquor. The absorption of the latter preparation is much higher above 300 mmu than that of the reference acid, so that at least this difference must be interpreted as a secondary phenomenon. A possible explanation would be that, under the strong acid conditions in the rayon pulp

cooking process, water is split off from the lignin molecule, giving rise to double bonds in conjugation with the benzene rings.

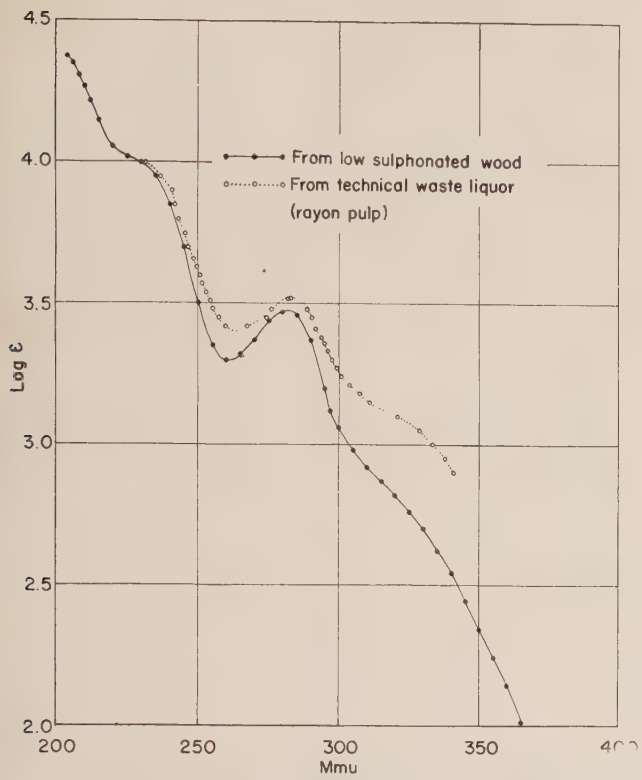

Fig. 8. Lignosulphonic acids from spruce wood (Ba salts in water)

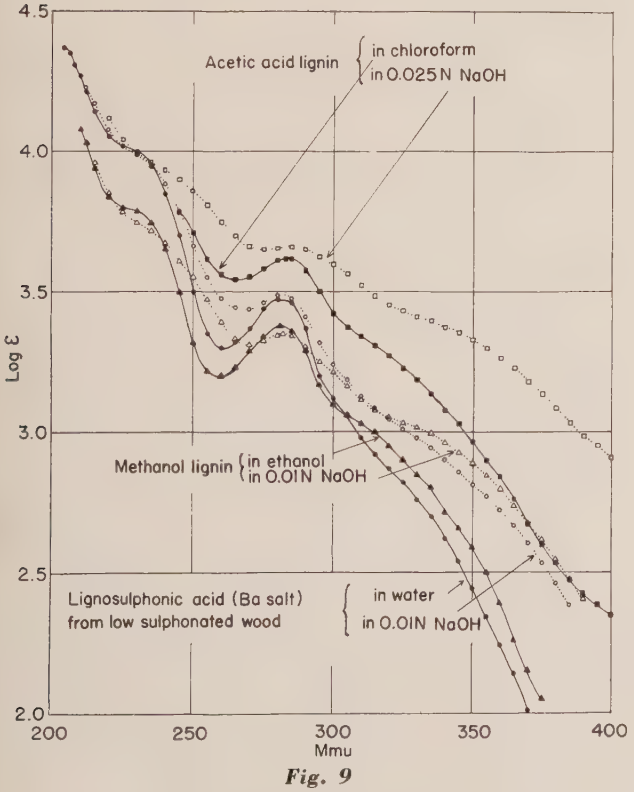

Fig. 9

In any case, it is evident that at least the isolated lignin derivatives contain some kind of larger chromophores (*13, 15*) than optically insulated benzene rings, though the proportion of these large chromophores must be small, since the absorption coefficient at about 320 mmu is relatively low. Hence, when, in 1931, Herzog and Hillmer (*11*) declared that double bonds conjugated with the benzene rings were excluded in lignin, they were at least mainly right.

Finally, the author would like to mention a few data regarding the influence of the pH value of the solvent on the absorption spectrum of some lignin preparations, although these investigations have only been started. Figure 9 shows the ultraviolet absorption curves of a few lignin preparations in neutral and in alkaline solvents. Considering each derivative separately, one will find that, in alkaline solution, the minimum has shifted toward higher ϵ-values and longer wavelengths.

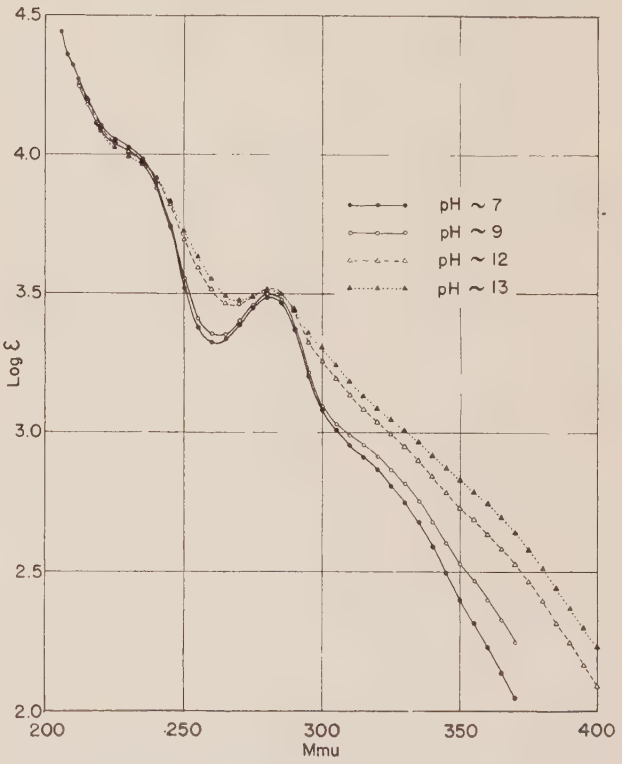

Fig. 10. Lignosulphonic acid from sulphonated wood in aqueous solutions

Moreover, the extinction coefficient above 300 mmu has increased corresponding to a strong darkening of the solution. A similar effect was reported by Häggglund and Klingstedt (*3*) in 1931 and by Goslawski and Marchlewski (*16*) in 1935, the latter working with pine lignin.

Figure 10 shows a series of spectra of the same lignosulphonic acid preparation at different pH's, indicating a gradual change in the spectrum with increased alkalinity. This change, which does not include the maximum, is at least partly reversible through neutralization. In 1947, Lemon (*17*) published a similar investigation of several phenolic compounds. In all cases, he found intensification of the absorption and shift of the maxima toward longer

wavelengths, these changes being largest with *p*-hydroxyketones and *p*-hydroxyaldehydes. In Fig. 11 a similar alkali-effect on the spectra of our lignin model substances is demonstrated. The wave-length shift in the long wave maximum is roughly proportional to the content of phenolic hydroxyls in the substances concerned. In the case of lignin preparations, however, the position of the maximum is practically unchanged in all cases thus far investigated. Hence, they probably contain very little phenolic hydroxyls.

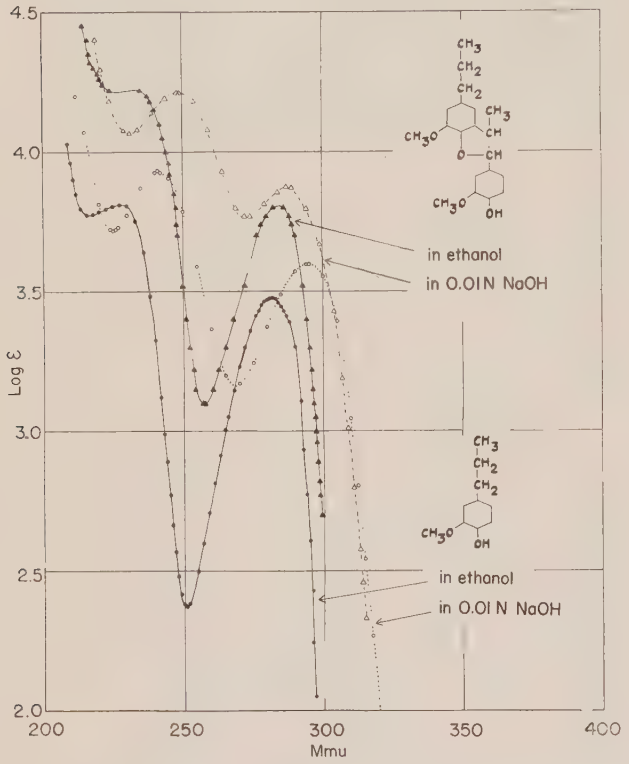

Fig. 11

In the case of lignosulphonic acid this is, of course, strong evidence against the ring-opening theory of the sulphonation mechanism.

Brauns's so-called native lignin (*18*), containing an appreciable amount of phenolic hydroxyls, also acts like a true phenol in respect to the influence of an alkaline medium on its ultraviolet absorption spectrum (Fig. 12). An even greater change is found in the case of the lignosulphonic acid prepared from native lignin. However, this may not be representative for all of the material, because only 20% (black spruce) and 60% (western hemlock), respectively, of the native lignin was dissolved during the cooking process.

Like lignin chemistry in general, the spectrochemistry of lignin is a field of research where rapid and definite results are not likely to be obtained. On the contrary, one soon finds how cautious one must be in interpreting experimental data and how necessary it is to repeat and control preliminary results before drawing definite conclusions.

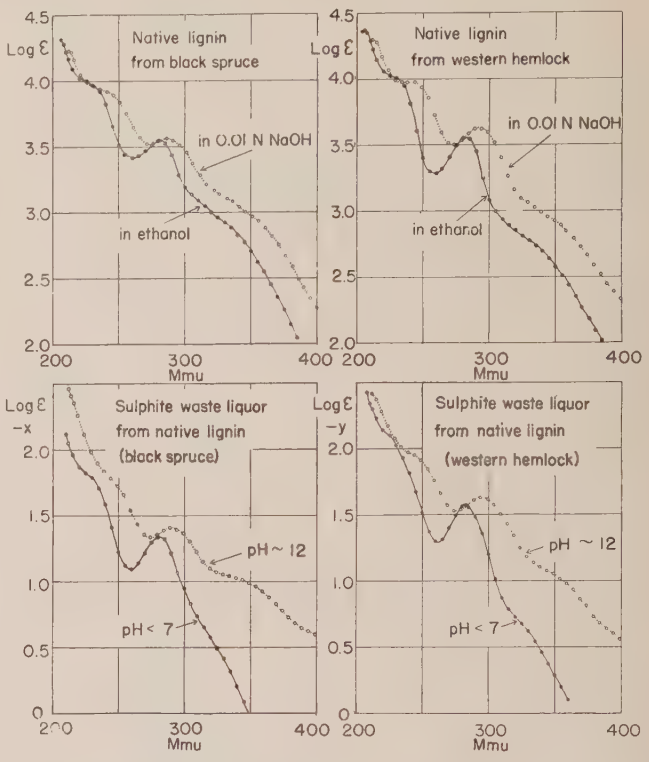

Fig. 12

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The Infrared Spectrum of Native Spruce Lignin

EDWARD J. JONES

The infrared spectrum of the native spruce lignin of Brauns was determined in film form and in Nujol dispersions from 3700 to 720 cm.$^{-1}$ Bands arising from hydroxyl and aromatic and aliphatic carbon-hydrogen groups are identified, and an aldehyde or keto carbonyl group in low proportion is established as the source of a weak band at 1663 cm.$^{-1}$ through comparison of the spectra of its methylation products. Tentative evidence indicating the aromatic and aliphatic carbon-oxygen source of other bands is given. Fractionation of native spruce lignin and comparison of the spectra of the fractions showed variation only in the strength of the carbonyl band. The spectra of five lignin preparations from spruce are compared and are shown to be basically similar; the spectrum of native aspen lignin was found to be quite different. Examination of a large number of so-called model lignin compounds failed to reveal any over-all spectral similarity to lignin. A group of carbohydrate and tannin materials were examined and their spectra contrasted with the lignin spectrum.

THE development of a new tool capable of aiding in elucidating the structure of lignin, the amorphous binding component of woody tissue, should be of particular value at this stage of intensive but inconclusive work on the subject. It was from this viewpoint that the present investigation of the application of infrared spectroscopy in this field was undertaken.

The importance of infrared spectroscopy in organic chemistry rests upon the fact that the natural frequency of vibration of most organic groups falls in the range of infrared radiation. An organic compound exposed to such continuously varying monochromatic radiation will therefore absorb energy in "bands" corresponding to these natural frequencies in the so-called fundamental vibration region from 2.5 to about 25 mu. The atomic masses involved and the strength of the elastic bonds are the determining variable as regards the values of these resonant frequencies. If these quantities are precisely known, the permissible resonant frequencies can be mathematically predicted. Such mathematical prediction of absorption spectra is not yet possible in any but the simplest or most symmetrical molecules, so that it is necessary, in going beyond this point, to rely upon empirically established fundamental absorption frequencies of specific chemical groups.

Native spruce lignin, as prepared by Brauns (*1*), was selected as the basic material for this investigation, on the basis that it represents the lignin of the wood as isolated by neutral solvents (ethyl alcohol or dioxane) and because of the availability of extensive chemical characterizations. Its chief weakness is that it represents less than 10% of the total lignin content of the wood.

In approaching the study of the infrared spectrum of lignin, a major problem was anticipated in finding suitable methods of preparing lignin samples for study, since very few solvents have sufficiently low absorption in the infrared to be useful. However, it was found that very satisfactory films could be prepared by evaporation onto salt plates in the case of native lignin and other soluble materials. Although dioxane is the most useful lignin solvent, dioxane solutions gave very poor results because of the high interfacial tension between the dioxane solution and the salt. However, it was found that, by filling a shallow cup comprised of a metal ring and salt plate base with absolute ethyl alcohol, adding a small proportion of dioxane solution, and allowing evaporation to take place slowly, the lignin was deposited as a strongly adherent clear film. The films thus prepared were nearly transparent to visible light and showed excellent resolution of the infrared bands.

With insoluble products, it was necessary to use mulled dispersions in Nujol. The most satisfactory absorption characteristics for lignin preparations were obtained from 10 to 25% dispersions spread as capillary films between salt plates. The aliphatic C—H regions are, of course, obscured by the oil.

A Model 12-B Perkin-Elmer spectrometer equipped with a General Motors breaker type amplifier and a Brown strip recorder was used in this work. A sodium chloride prism was employed to cover the range 2.5 to 14 mu. The instrument was operated in a room maintained at 80°F. and below 30% relative humidity. The wave-length scale was calibrated from the data of Oetjen, Kao, and Randall (*2*) for water vapor, ammonia, and carbon dioxide, and atmospheric bands superimposed on each recording were checked for constancy of calibration. Open-path (I_0) and sample-in (I) energy curves were recorded for each run, and transmission data ($T = I/I_0 \times 100$) were computed manually except for the 1200 to 2000 cm.$^{-1}$ water-vapor region, where a mechanical computer, an adaptation of the IPC mechanical integrator (*3*), was employed.

The absorption spectrum of native spruce lignin as

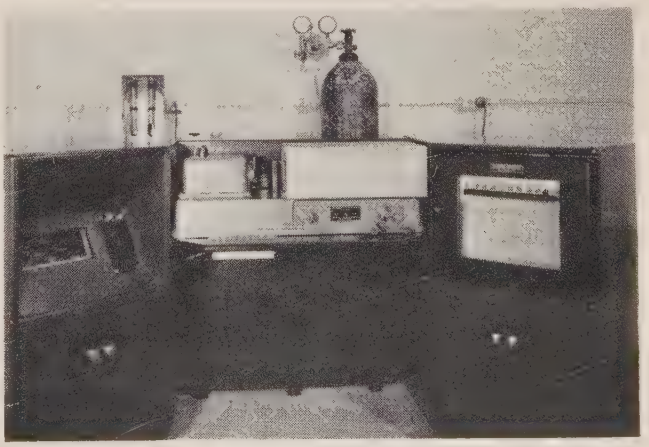

Fig. 1

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obtained from a thin film is shown in the accompanying figure. The plot is on the basis of percentage transmission against frequency expressed as the wave number in reciprocal centimeters. The chart covers the range 2.7 to 14 mu, which is approximately the maximum useful extent of the sodium chloride prism.

An identical spectrum is obtained in Nujol dispersions, with the exception of the three bands shown as broken lines. These appear in the film but not in Nujol. Although there is evidence to indicate that they may be due to absorbed dioxane, this has not been conclusively demonstrated.

A basic philosophy that has been adopted in the study of this spectrum is that, in this initial phase, it is highly desirable to restrict interpretation to direct spectrochemical evidence and not to lean any more than necessary on chemical data for support.

From this standpoint, the first question to be raised was with regard to the homogeneity of the material being studied. Evidence on this point was gained through fractional precipitation of the native lignin and comparison of the infrared spectra of the fractions obtained. Six fractions of approximately equal size were separated by addition of benzene and petroleum ether to a solution of the lignin in dioxane. Each fraction was thoroughly washed, redissolved, and reprecipitated under identical conditions.

The infrared spectra of these fractions as determined by the standard film technique revealed a very interesting relationship. On a quantitative basis, with the exception of the bands in the carbonyl region, the infrared spectra of the fractions show only slight and nonspecific variations from the spectrum of the original native lignin. A definite progressive change in the relative strength of the 1655 to 1665 cm.$^{-1}$ band, which will be shown to be produced by an aldehyde or keto carbonyl group, is quite apparent, however; it is very weak in the most soluble fraction and relatively strong in the least soluble fraction.

The fact that the infrared spectra of the fractions are essentially identical, except for the carbonyl band, definitely shows that this separation has not been effected through major chemical differences. Whether the observed variation in carbonyl proportion is in itself sufficient to produce the fractionation must remain an open question until a reliable method for measuring molecular weight can be applied to such fractions. If the fractionation is primarily on the basis of molecular weight, which is much more probable, these results would seem to indicate that polymerization of lignin monomers cannot be through the carbonyl group.

The important conclusion with respect to the present investigation of infrared spectra is that the basic pattern of the absorption spectrum of native spruce lignin is found to be preserved through this fractionation. When this is added to the findings that the same characteristic pattern is obtained from total spruce lignin preparations isolated by a number of different methods, and that this spruce lignin spectrum is readily distinguishable from the spectra of all other materials run, the evidence is rather strong that the term "lignin" does designate a unique and basically homogeneous structure.

In order to obtain a background for valid interpretation of the lignin spectrum, it was necessary to build up a reference library of spectra of compounds of known structure. The infrared spectra of many organic compounds have been published, and empirical charts have been drawn which show the principal absorption bands of many organic groups, among the most important of such reviews being those of Williams (*4*) and Barnes and co-workers (*5*). However, the lack of standardization of instruments and methods of presentation of data made it highly desirable to work directly from spectra obtained on one instrument, as supported by the accumulated data in the literature. In addition, the spectra of many of the compounds of direct interest in the lignin field have not been published. By use of the large number of highly purified samples that have been accumulated at the Institute and with the generous assistance of Holger Erdtman of Kungl. Tekniska Högskolan, Stockholm, who gave samples of a number of dieugenol and diisoeugenol type compounds that have been synthesized in his laboratory and used in extensive ultraviolet studies, it has been possible to establish a sizable album of spectra that illustrate many of the structure-absorption relations in which we are interested. The compounds of known structure examined were: benzene, toluene, ethylbenzene, phenol, vanillyl alcohol, vanillin, eugenol, eugenol methyl ether, isoeugenol, isoeugenol methyl ether, flavanone, benzylideneacetophenone, quercetin, conidendrin, tetrahydrodehydrodieugenol dimethyl ether, inactive guaiaretic acid dimethyl ether, α-(3,4-dimethoxyphenyl)-β-(3-propyl-5,6-dimethoxyphenyl)propane, dihydrodehydrodiisoeugenol methyl ether, dehydrodiisoeugenol methyl ether, and pinoresinol dimethyl ether.*

In comparing the spectra of these compounds of known structure with the illustrated spectrum of native lignin, two generalizations are at once apparent. The first is the relative simplicity of the lignin absorption curve. This is a known characteristic of the spectra of high polymer materials; the large number of primary and secondary linkages apparently suppresses many of the normal modes of vibration of the simple building unit without seriously impeding the resonant vibration of the major chemical groups (*6*). The second basic conclusion is that it is futile to try to compare the infrared spectrum of an unknown material with those of known compounds and state that the spectrum of the unknown is "like" that of a particular compound unless the two curves are identical or nearly so. Since lignin is obviously quite different from any of the simple compounds studied, it is not surprising that its infrared absorption curve cannot be even closely matched with any of the other curves obtained.

The spectra determined in this study were found to comply closely with the general empirical rules of group-chemical absorption band relations given in the literature. The most important conclusion reached, however, was that these rules must be weighed in terms

* The complete infrared spectra of these and all other materials mentioned in the paper are available in the original dissertation. It is desired to thank Professor Erdtman and all others who so generously contributed samples for this work.

of relative invariability. This is taken into account in the following interpretation of the native spruce lignin spectrum.

Possibly the most invariant bands to be found in the infrared spectrum are the pair occurring at 1600 and 1500 cm.$^{-1}$ in aromatic compounds. These are a function of the aromatic nucleus and are only slightly shifted by type or degree of substitution. Their relatively strong appearance in the lignin spectrum may be justifiably taken as evidence of the basic aromatic nature of the material.

Although aliphatic C—H bands are somewhat less sharply denoted, the combination of several definite bands in the 3000 to 2800 cm.$^{-1}$ region, accompanied by proportionally strong bands in the 1480 to 1350 cm.$^{-1}$ region, appears sufficient to establish the presence of saturated aliphatic groups. The relative strength of such bands in these sections of the lignin spectrum indicates a fairly large proportion of saturated C—H groups in the material. Although the relative number and strength of such bands are known to vary considerably with the degree of hydrogen substitution ($\equiv CH$, $=CH_2$, $—CH_3$), we are not prepared to attempt any such differentiation in the lignin spectrum at present.

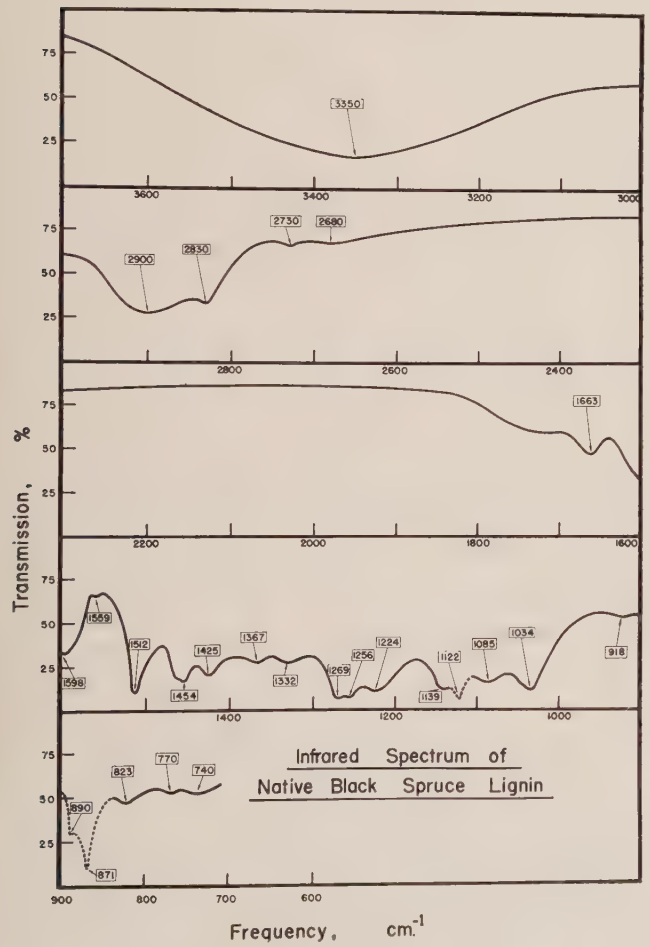

Fig. 2

A third group that is sufficiently unique in its mass-bond strength properties to command a comparatively "free channel" is the hydroxyl group. Absorption bands appearing in the range 3700 to 3100 cm.$^{-1}$ may be taken as strong evidence for the presence of OH groups (in compounds free of nitrogen, where NH groups absorb in this region). Free hydroxyl groups, as found in gases or dilute solutions, produce sharp bands in the 3700 to 3500 cm.$^{-1}$ region. The shift of such bands to lower frequency in concentrated solution and solids is one of the most fundamental demonstrations of hydrogen bonding. The broad strong band in the lignin spectrum at 3350 cm.$^{-1}$ may then be assigned to hydroxyl groups exhibiting rather strong hydrogen bonding. The poor dispersion of the sodium chloride prism in this region may well be responsible for the lack of resolution of this band into several minima that might be produced by varying types of hydroxyl groups of varying degree of bonding.

Beyond this point it is necessary to substantiate assignment of different bands in the spectrum to specific groups with more direct evidence. To this end, the various methylation products of native spruce lignin have been most useful.

The weak but definite band that appears in the lignin spectrum at 1663 cm.$^{-1}$ falls in a region commonly associated with aldehyde or ketone carbonyl groups or aliphatic double bonds. The fact that this band is absent in the spectrum of methyl alcohol–hydrochloric acid methylated native lignin clearly establishes this band as that of an aldehyde or ketone carbonyl group. The fact that it is unchanged by diazomethane or dimethyl sulphate methylation adds no further information since it has been shown by work on simple compounds that enolization does not affect absorption in this region (*7*).

In the discussion of carbonyl absorption, attention should be given to the interesting plateau in the lignin spectrum from 1730 to 1700 cm.$^{-1}$ This is the normal absorbing region of acid or ester carbonyl groups. This structure persists throughout the six methylated lignin spectra with the appearance in the case of the methyl alcohol–hydrochloric acid treated products of a minimum at about 1710 cm.$^{-1}$

The proportionate disappearance of the 3350 cm.$^{-1}$ band with methylation confirms the identification of its hydroxyl group origin.

Additional but less specific information was gained from the spectra of the methylated samples:

The fact that the over-all spectra of these products were very similar to that of the native lignin indicates that no fractionation or drastic structural changes took place in the various treatments.

The small but consistent gain in absorption at about 1460 to 1465 cm.$^{-1}$ indicates that this absorption must be at least partially due to the CH_3 unit in the methoxyl group.

Bands appearing below approximately 1400 cm.$^{-1}$ are as likely to originate from vibrations arising from general molecular structure as from specific groups and, therefore, must be interpreted with caution. However, aromatic or unsaturated carbon to oxygen linkages are known to give rise to bands in the region 1260 to 1190 cm.$^{-1}$ The strong bands within these limits in the lignin spectrum at least suggest these

groupings as their source, and a slight but consistent change in the region on methylation indicates the contribution of the new methoxyl groups.

Saturated carbon-oxygen-carbon linkages are commonly found to produce bands in the 1125 to 1075 cm.$^{-1}$ region. Although the absorption in this case is uncertain because of the unknown origin of the 1122 cm.$^{-1}$ band, methyl sulphate methylation produces a definite increase in the absorption in this region.

To summarize the conclusions reached with respect to the lignin spectrum:

The pair of strong bands at 1598 and 1512 cm.$^{-1}$ in the lignin spectrum are identified as characteristic of the aromatic nucleus on the basis of strong empirical evidence. In like manner, the bands at 2900 and 2830 cm.$^{-1}$ and 1454 and 1425 cm.$^{-1}$ are assigned to a moderately high ratio of saturated aliphatic C—H groups. The 3350 cm.$^{-1}$ band is positively identified as being derived from hydroxyl groups by its progressive disappearance on methylation. The 1663 cm.$^{-1}$ band is demonstrated to represent an aldehyde or keto carbonyl group through its removal on methyl alcohol–hydrochloric acid methylation. Evidence suggesting, but not proving, the aromatic C—O and saturated C—O origin of some of the bands in the 1260 to 1075 cm.$^{-1}$ range has been discussed.

This is as far as can be gone at present in identifying the source of the absorption bands in the native lignin spectrum. Further work will bring out other chemical structure–absorption spectrum relations, but a number of bands, particularly at the lower frequencies, will undoubtedly have to be assigned to general characteristics of the material, rather than to specific groupings.

In going to the next major application of the infrared spectrum—its use as a "fingerprint" of a material —all the absorption bands assume nearly equal importance.

A start has been made toward the comparison of the native lignin spectrum with spectra of lignins isolated by other methods and with spectra of other related materials. Because of the insolubility of many of these preparations, most of the comparisons are of spectra obtained with Nujol dispersions.

Klason, Willstätter, alkali, periodate, and Freudenberg spruce lignins were examined in Nujol. The spectra obtained were surprisingly similar to that of native spruce lignin in Nujol. The spectra of the Willstätter and periodate lignins were practically identical; that of the alkali lignin was very similar except for the noteworthy absence of the 1663 cm.$^{-1}$ carbonyl band; Klason lignin showed almost complete absence of hydroxyl bands and no carbonyl band, but was very similar in other regions; the spectrum of Freudenberg lignin showed several important variations among the unidentified bands.

The spectrum of native aspen lignin, on the other hand, although showing a generally similar pattern to that of native spruce lignin, was found to be considerably more complex. There is a far greater difference between the spectrum of this native hardwood lignin and native spruce lignin than there is within the group of the six spruce lignins isolated by different methods.

The Northern Regional Research Laboratory of the Department of Agriculture very generously supplied a sample of the synthetic material known as Russell lignin. Although the spectrum of this material shows a number of bands at approximately the same frequencies as found for native spruce lignin, such as the aromatic nucleus pair, aliphatic C—H and hydroxyl bands, etc., the spectra show quite marked differences. The most striking example is the very strong carbonyl band of the synthetic material—comparable in strength with that of vanillin.

Erdtman included in the set of samples furnished us an interesting series of three barium lignosulphonates of varying sulphur content. The spectra of these materials as determined in Nujol dispersions, particularly for the low sulphur (4.2%) sample, were very similar to the spectrum of native spruce lignin. The outstanding evidence obtained from the series was the disappearance of absorption bands in the carbonyl region with increasing degree of sulphonation.

Samples of purified chestnut, quebracho, and redwood tannins and redwood phlobaphene were run as films from dioxane-ethyl alcohol. The partial insolubility of several of the group did not prevent preparation of uniform dispersions.

For the first time a group of materials was found whose spectra were of the same general type as lignin, as contrasted with low-molecular weight crystalline or liquid compounds. The spectra were quite distinguishable among themselves and from the spectrum of lignin, however. The outstanding features of interest are the very strong acid or ester carbonyl band in the chestnut tannin curve and the weak plateau effect in this region in both the quebracho tannin and the redwood tannin and phlobaphene spectra. No definitely significant difference could be found between the redwood tannin and phlobaphene absorption curves.

It is believed that this work adequately demonstrates the potential usefulness of infrared spectroscopy in the lignin field. It is hoped that these necessary exploratory investigations can be extended and applied as rapidly as possible, so that the technique may assume its proper role as a powerful physical tool in the chemical studies of the structure and reactions of lignin.

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Treating Water for Use in Paper Mills

D. B. JONES and W. H. WEITZEL

Water requirements for use as boiler feedwater make-up and process are dependent on the physical design of the power plant and the quality of the manufactured product. Final decision as to the selection of treating equipment is dictated by individual plant requirements and characteristics of the water supply. Adoption of supplementary treatment is often necessary to compensate for inadequacies of plant facilities.

THE paper industry is an outstanding example of a manufacturing process where water is as important as the raw material used for manufacturing. Since the paper industry is spread over a wide geographical area, the physical and chemical characteristics of the various water supplies differ greatly and present a wide variety of problems in fitting them for various uses in the paper mills.

In considering these problems, it has been found convenient to classify them in two divisions thus, those which involve change of phase, and those which do not involve change of phase. By change of phase, conversion of water into steam is meant. Thus, those problems involving change of phase of water are those of the power plant, and of the condensate system in which the reconversion of steam into water has occurred. Those problems which do not involve change of phase are those associated with the use of water in the actual manufacturing processes.

Usually the source of water available will supply both the power and process requirements. The use of this water for the generation of steam will result in the concentration of impurities in the boilers while the inherent impurities in the process water are not subjected to concentration since there is no change in phase. The factors governing the impurities which must be contended with will be governed by the stability or variation in the water supply. If the characteristics of the water are subject to variation consideration must be given as to whether these are due to natural causes or man-made. Natural variations may be experienced throughout the year or may be seasonal. If seasonal this may mean that there are only a few days during the year when certain types of contamination will interfere with the mills' operation. Must a treating system be adapted to cope with such "short term" contamination? If variations are caused by industrial wastes, can any change be expected in the light of state and federal pressure to clean up pollution of the water sources? This may mean consultation with government and industrial representatives to discuss future plans so that a high capital expenditure for treating equipment to handle industrial waste contamination will not be a white elephant after two or three years use.

In the selection of the treatment method further study must be given to the characteristics of the water supply with respect to its use as boiler feedwater make-up and in the manufacturing process. What are the undesirable constituents present in the water supply that is under consideration? Are the process water standards sufficient to produce a satisfactory boiler feed water make-up supply? In most cases the standards imposed by the process requirements will not be as demanding as those required for boiler feedwater make-up. Process requirements do not necessarily demand water low in hardness concentration, but do require reasonable clarity, minimum discoloration, and that it be of a noncorrosive nature. In some cases water free of dissolved iron and manganese is mandatory. On the other hand boiler feed water requirements call for a make-up water similar to process water with added refinements of low hardness, low solids, etc. Water of this quality is seldom obtained from treating plants supplying process needs. However, the initial step in the preparation of the water supply may eliminate duplication of the equipment in preparing the water for boiler feed water use.

Waters considered satisfactory for the manufacture of rough kraft or board cannot be considered satisfactory for fine bond or photographic grade papers. Thus it can be seen that the degree or refinement of treating equipment for the preparation of process water use will vary with the quality of the product being manufactured.

Since the process water does not undergo change of phase as does the boiler feed water, the preparation of this water from the standpoint of reducing the hardness, and total solids, is not as critical as in the case of boiler feed water supply. Needless to say a soft water supply for process use is advantageous in many respects but not essential. Some mills are so located that their water supply could be classed as very soft (less than 50 p.p.m. of hardness expressed as calcium carbonate), whereas other mills have to contend with hardness values in excess of 250 p.p.m. as calcium carbonate. The emphasis on preparation of process water for plant use is primarily placed on clarification of the water supply if turbid. The further removal of color, iron and manganese, hydrogen sulphide, and hardness will be dictated by plant needs. If the supply is free of turbidity to begin with, this may suffice for some mills. Other mills may find it necessary to get rid of hydrogen sulphide or dissolved iron and manganese that may be present. Prechlorination as well as postchlorination may be necessary to prevent slime growths. All of these variables are interrelated with the finished product and are of course different for the different types of mills.

The installation of clarification, color removal, iron and/or hydrogen sulphide removal equipment for eliminating one or more of the objectionable impurities from the plant process supply does not necessarily

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provide a trouble-free water. Clarifying and/or color removal processes properly carried out will produce sparkling clear waters of low turbidity and low color content but do not effect the hardness of the supply to any appreciable extent. Aeration plants for removal of dissolved iron and/or hydrogen sulphide reduce the concentration of these objectionable impurities to a satisfactorily low level but at the same time increase in dissolved oxygen concentration of the water. The resulting increase in dissolved oxygen concentration increases the corrosive characteristics of the water so that corrosion and consequent iron pickup in the distribution system occurs. In some cases the resulting iron pickup may be sufficiently great as to equal the original dissolved iron concentration in the supply. Iron and manganese zeolite removal units reduce the concentration of these two impurities to acceptable limits but do not affect the hardness present in the supply.

In many cases color removal has to be carried out at relatively low pH values in order to produce an effluent water of sufficiently low color content. Unless steps are taken to combat the aggressiveness of this low pH water, corrosion in the distribution system could occur.

Plants obtaining some degree of softening, using lime alone, or lime and soda ash in conjunction with their clarification process must protect themselves against after precipitation in the plant effluent. Stabilization methods for the prevention of after precipitation have been advanced by Hoover (*1*) and by Rice and Partridge (*2*).

Unwanted softening of the process water often occurs at points in the distribution system where it is undesired and the byproducts in the form of lime deposits are definitely detrimental to continuity of operation and the quality of the finished product. Waters high in temporary hardness when heated either by direct contact or indirectly by heat exchangers form objectionable deposits at the point where the temperature of the water is elevated. Similar waters coming in contact with alkaline pulp or recirculated alkaline liquors also yield undesirable lime deposits.

One specific case for the elimination of scale forming deposits has been presented (*3*). In this paper the authors describe how, by the application of several parts per million of sodium metaphosphate at a specific point in the system, they were able to minimize and greatly reduce formation of objectionable lime deposits. At points in the system where deposition of calcium carbonate occurs due to heating, prevention of such deposit may be inhibited by the application of 2 to 4 p.p.m. of metaphosphate. The feed of treatment material to the system can be accomplished by means of a small proportioning type chemical pump. The use of a pump is not essential providing other means of readily controlling the rate of feed of chemical to the water supply is available. In systems under pressure the proportioning chemical pump usually provides the best and most controllable means for feeding the material.

For processes requiring hot water, using 1,000,000 gallons or less of water per month, and where scaling of the heat-exchange units occurs, it can be eliminated by the use of Micromet. This material is a slowly soluble form of metaphosphate dissolving at the rate of 25% of its volume per month. The material is introduced into the system by means of a bypass feeder located on the water supply line. The initial charging of the bypass feeder is based on the quantity of water consumed per month, and monthly additions of the material thereafter will be 25% of the initial charge to the feeder. As mentioned above, the application of this phosphate is limited to plants for processes having hot water requirements of less than 1,000,000 gallons per month.

Encrusting deposits are not limited to calcium carbonate alone. Calcium sulphate deposits do occur from time to time and can be just as troublesome to the operator as calcium-carbonate scale. Similarly, their deposition can be minimized and inhibited by the threshold amounts of metaphosphate. A specific example of this is the parchmentizing of paper. In this process the fresh water flow is counter to the flow of acid and paper. With a water high in calcium content, a gradual build up of calcium sulphate occurs on the rolls which means shutting down and cleaning the machine. The diluted acid is collected from the bottom of the machine and concentrated in a two-stage evaporation process and returned to the head end of the machine. In addition to the build up of calcium sulphate on the rolls, considerable scaling of the evaporator occurred as a result of the concentration process. The addition of 3 p.p.m. of metaphosphate to the water going to the machines eliminated deposits on the rolls. A supplementary feed of 3 p.p.m. to the dilute acid storage tank ahead of the evaporators has enabled the plant to wash the bulk of the deposit from the evaporators each week. Approximately once every three months the evaporators require a light boil out. Prior to the installation of the above described treatment, the plant attempted to boil out evaporators once each month. These results were never considered too good, with the result that the evaporator coils were replaced several times yearly.

Change of phase occurs at two points in the water-steam cycle of the power plant. One involves the generation of boiler water into steam and the other involves the condensation of steam to water. At both points in the system where the change of phase occurs characteristic problems may arise that should be carefully considered prior to heavy capital expenditure for treating equipment.

The evaporation of boiler water to clean dry steam decrees that all impurities in the boiler be left behind, and that such impurities increase since the make-up water is less pure than the steam it replaces. The types and concentrations of these impurities must be carefully controlled since at high temperatures their solubility relationships are major factors in determining whether boiler tubes will continue to function or fail as a result of excessive deposition of insoluble materials at high heat transfer surfaces. It is common knowledge that the feed water hardness must be reduced to reasonably low values, the degree of reduction depending upon the physical design of the power plant. This will undoubtedly require additional treating requirements beyond that obtained in the process water treating plant. The possible needs of the power

house should be given careful consideration when a study of process treating requirements is made, so that adequate capacity can be provided. It is possible that the process water treating plant can provide certain preliminary functions that will be required before the water can be used in the power house. For example, with the use of exchange type softeners for boiler feed water make-up softening which require water of high clarity and low dissolved iron concentrations, it may be possible to take advantage of any plant process water treating equipment that is capable of delivering such a water.

Although it is not the purpose to discuss water softeners and their operation, it is known that when erecting a new power plant requiring the installation of new feed water treating equipment, there is a wide selection from which a choice can be made to give almost any quality of water that is desired. However, the great majority of plants must do what they can with the equipment at hand and a number of problems often arise with which the softeners cannot always cope. Secondary phosphate treatment in the boilers allows a wide tolerance of softener operation where hardness reduction is the primary function and prevents the formation of calcium scales on heat-transfer surfaces. However, the sludge produced from the precipitation of boiler feed water hardness has been troublesome to a certain degree depending upon the amount of sludge formed, the type of boilers, boiler ratings, boiler pressures, and the rate of heat transfer at the tube surfaces. At low pressures and temperatures organic dispersives have been used with varying success. At higher temperatures and pressures the use of these agents is at times impractical and other approaches to this problem of sludge must be considered. It has been found in the laboratory that samples of objectionable sludge deposits frequently show a magnesium to calcium ratio much higher than that present in the make-up water. Furthermore this high magnesium content is generally combined as the hydroxide and/or phosphate, which adhere more readily to the boiler surfaces than does the calcium phosphate. These magnesium compounds appear to serve as a binder or sponge for the calcium phosphate which normally would remain in circulation and be removed through blowdown. Many other analyses of sludge samples collected from boilers where sludge deposits were not a problem indicate that the magnesium is present as the silicate in the form of serpentine. Also, in such samples the ratio of magnesium to calcium more nearly approaches that in the make-up water, therefore, it appears that if magnesium can be precipitated as the silicate, sludge problems can be readily solved. To do this a study of existing conditions must be made. What is the silica concentration of the raw and treated waters? What silica values do boiler water analyses show? Are boiler water phosphate concentrations greater than necessary? All of these answers may show that there is insufficient silica to precipitate the magnesium as the silicate in which case feed of silica in the form of water glass is desirable. There are a considerable number of plants operating at pressures from 150 to 600 p.s.i. where the feed of silica has done an outstanding job in eliminating sludge deposits.

Where precipitation type softeners are used, the silicate is fed with the lime and soda ash solution and controlled on the basis of boiler water residuals. This has been equally beneficial to the filters since much of the magnesium is precipitated in the softener as the silicate rather than the hydroxide and less caking of the filter media occurs and more complete removal of sludge from the filters can be obtained during backwash.

Where precipitation type softeners are not used, feed of silicate may be direct to the feed water or to the boilers. Control of additions is established on the basis of feed water characteristics and operating conditions. Phosphate residuals are held at the lowest possible concentration in accordance with safe operation. The purpose of this is to eliminate the mass action effect of the phosphate on the magnesium. The results of this type of treatment have been so outstanding that some plant operators have stated that they would prefer to be without phosphate rather than silicate. This is, of course, a rather strong statement but it does indicate how some operators feel about the job silica has done in their boilers.

By establishing the correct program of boiler water conditioning with the use of preliminary softening and supplementary treatment, the primary function of the boilers, the generation of clean dry steam, can be considered.

Great progress has been made in the development of internal baffling and steam purifiers to reduce to a minimum entrainment of boiler water in the steam leaving the boilers. Closely allied to this development has been the establishment of closer control over the water conditioning programs that are established to maintain the correct chemical equilibria within a boiler thereby eliminating foaming and priming. Also, better mechanical regulation of water levels has aided by holding nearly constant water levels over a wide range of operating conditions. All of these factors have contributed to the production of clean dry steam. However, those constituents actually dissolved in the steam escape these means of retaining them in the boiler and pass over into the steam mains and later may be a factor in operating difficulties.

A paper mill steam load is often characterized by sudden fluctuations in steam demand. Due to the sensitivity of various types of boilers to sudden steam demands this may lead to carryover difficulties that are difficult to combat. Although fluctuations in steam demands cannot always be anticipated there may be times when by informing the power plant that increase in steam demand will be required, the power plant may be able to take needed precautions. Also, frequently the process end of the plant can aid in this problem. For example, a particular problem of turbine deposits arose at a paper mill where boilers were operating near the maximum boiler ratings. Deposits had been found to build up on the turbine blades sufficiently rapid to require washing of the turbines every six or eight months. During an investigation of steam quality, sufficient data were accumulated to prove rather conclusively that carryover occurred when digestors requiring approximately 15,000 pounds per hour of steam were placed on the line. This sudden additional steam requirement on top of the relatively

high ratings on the boilers was sufficient to entrain boiler water in the steam and deposit the solids on the turbine blades. It was found that by opening slowly the valves on the steam lines leading to the digestors the steam demand at the boilers was more gradual and carryover was decidedly less pronounced. Cooperation of the digestor operators was requested and carryover ceased to be a problem.

The most common vapor contaminant of steam is carbon dioxide. It may enter the boiler as naturally occurring bicarbonate in the raw water or it may have its source as a water conditioning chemical. When these are exposed to boiler temperatures as they enter with the feed water, at least partial decomposition occurs forming caustic soda and liberating carbon dioxide which will pass off with the steam. At each point in the system where steam is condensed the carbon dioxide redissolves in the condensate and may accelerate corrosion due to the low pH conditions which result. This type of corrosion is generally characterized by grooving in the bottom of condensate return lines and frequent failures at threaded joints may be experienced.

This type of corrosion can be and has been a serious problem in the drying rolls of paper machines. Such a problem may be difficult to solve since it requires considerable reduction or neutralization of the carbon dioxide. The carbon dioxide content of the steam may at times be lowered through softener control manipulation and more effective deaeration. In extreme cases, acid feed followed by aeration, deaeration, and pH adjustment of the feed water with caustic soda will reduce the carbon dioxide released in the boilers to a minimum. Also, where soda ash is used as a water conditioning chemical, there may be the possibility of substituting caustic soda if it will perform an equally satisfactory function.

Some use has been made of certain organic amines that are added to the feed water system following the deaerating heater. These amines vaporize in the boilers and pass out with the steam. When condensation occurs the amines go into solution and neutralize the effect of the carbon dioxide. When the condensate is deaerated the carbon dioxide is driven off along with a portion of the amine. However, in a water-steam cycle the principal loss is due to condensate not returned to the power house. The economy of treatment depends upon the per cent of condensate returns and potential concentration of carbon dioxide in the feed water which varies with the total amount of make-up water required by the boilers. Since the expense incurred from corrosion may be considerable, the use of these relatively expensive organic amines may prove to be economical in those plants requiring relatively low make-up. The effectiveness of this type of treatment can be readily determined by the use of corrosion test specimens inserted in the return condensate lines. Checks made before and after treatment will show to what extent corrosion has been inhibited and future steps may be based upon these results.

Several problems the solution of which depends to a marked degree on the characteristics of the boiler feed water make-up have been discussed. The most elaborate treating plant available cannot overcome contamination entering the system following the softener. In a paper mill this contamination may be in many forms. In the past, caustic and acid liquors reaching the boilers have been agents that radically upset boiler water concentrations. All paper mill engineers have recognized this problem and they have gone to considerable effort and expense to solve this difficulty. Extensive use of conductivity equipment actuating an alarm or automatic valves has aided considerably in reducing the frequency of such contamination actually reaching the boilers. However, engineers have not always been equally diligent in eliminating other types of contamination that are not as spectacular in their effects but may be equally detrimental to over-all operation. The most pronounced example of this type is raw water contamination. This problem is generally found in the older mills and tracing down the source of such contamination is sometimes a very difficult problem. It has been found that in condensate return systems where reciprocating pumps have been used for returning condensate to the power house, quite frequently the temperature of the condensate is sufficiently high to cause steam binding of the pumps if some cooling water is not added to the suction side. In most cases raw water is used for cooling purposes, and the greatest problem is to limit the amount of such water added to the system. In most cases where severe condensate contamination has been found, investigation reveals that the valves on the cold water line leading to the condensate return pump suction are wide open and that little or no attempt is made to regulate the amount of water used. Quite frequently the amounts could be cut materially if only sufficient cooling water was used to assure satisfactory operation of the condensate return pumps. The far reaching effects of such contamination cannot be over-emphasized. It will increase the hardness of the boiler feed water and require an additional amount of chemicals for secondary internal treatment. It may also increase the feed water hardness above the critical point where stage heaters and economizers will suffer from scale deposition. It will add to the suspended solids content of the boiler water and where the raw water supply is high in bicarbonate will also increase the potential carbon dioxide content of the steam. Therefore, this problem is very real and must be attached in an aggressive and thorough manner. The ultimate solution would be, of course, the installation of a more up-to-date return system and any required cooling could be done by heat exchangers rather than by direct contact. However, where engineers recognize this problem, education of operators to carefully control any cooling water required by the system should be attempted.

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The Chemical Analysis of Western Woods

Part II. Douglas Fir Bark Analysis

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Douglas fir bark and its mechanically separated components were analyzed by conventional wood analysis methods. The application of the cellulose procedures to these materials appears to be impracticable. Cork is relatively insoluble in 72% sulphuric acid; hence, analytical specimens containing cork will give inaccurate lignin values. The "lignin" residue from the short needlelike fibers contains less than one-half of the methoxyl content of softwood lignins. An acetic acid content of 3.3 to 5.1% of the fibrous component is indicated.

THIS article summarizes the experimental findings when conventional wood analysis procedures are applied to whole Douglas fir bark and to certain of its fractions. Previous investigations (*3*) on the extractives from Douglas fir bark have indicated a tannin content of 7.6 to 18.3%, a wax content of 3.5 to 6.0%, and a dihydroquercetin content between 5 and 10%. Successive extractions with petroleum ether (boiling range, 140 to 160°F.), acetone, and hot water gave an extractive content of approximately 30% of the dry weight of the bark. Clermont and Schwartz (*1*) found 42.9% extractives by successive extractions with alcohol-benzene, alcohol, and hot water. Although the chemical composition may vary widely, it appears that Douglas fir bark is rich in extraneous materials.

The material used in the analyses was collected in November, 1947, within one month of the time of felling, from trees growing in the Coast range mountains about 20 miles west of Corvallis, Oregon. A 300-pound lot of bark was removed from various parts of several logs on the ground to obtain representative samples from commercial logs.

For the purposes of this study, Douglas fir bark was mechanically separated into three components: cork particles, short needlelike elements, and a reddish-brown powder. The last two substances seem to diminish in old bark; hence, there is a correspondingly higher percentage of cork in such bark. The entire lot of wet bark, immediately after collection, was passed through a Gruendler hammer mill and then room-dried to about 15% moisture content. A part of the dry bark was then screened on a Rotap. Fractions larger than 10 mesh and finer than 200 mesh were obtained. The cork particles were most highly concentrated in the coarse material.

Samples taken for chemical analysis included (a) the hammer-mill-treated whole bark, ground further in a Wiley mill to pass a 40-mesh sieve; (b) short needlelike elements passing a 40-mesh sieve but retained on a 60-mesh sieve; (c) short needles passing a 60-mesh sieve and retained on an 80-mesh sieve; (d) a bark powder passing a 200-mesh sieve, and (e) cork flakes obtained by comminuting coarse bark particles in a ball mill and screening.

The samples were analyzed by the procedures given in Part I of this series (*4*) and, in addition, the acetyl group content was determined by a modification of the procedure of Freudenberg and Harder (*2*). It was found that more reliable data could be obtained in the acetyl group determination by using a 2-gram instead of a 0.3- to 0.4-gram analytical sample and by using 0.1 normal instead of 0.5 normal sodium hydroxide solution. When the smaller sample and the stronger base are used, the volume of standardized solution consumed is too small to permit accurate measurement. Preliminary tests for saponification of a prepared ethyl acetate–ethanol solution indicated that saponification of the ethyl acetate, under the prescribed experimental conditions, is as complete with 0.1 normal sodium hydroxide solution as it is with 0.2 or 0.5 normal solutions. Data obtained in this investigation of Douglas fir bark are shown in Tables I and II.

The analytical data show that the cork fraction is largely insoluble in the 72% sulphuric acid used in the conventional lignin determination; therefore, an accurate quantitative lignin analysis is not possible. The methoxyl content of the "lignin" residue from the whole bark sample was 6.12%, whereas the "lignin" residue from the needlelike elements had a methoxyl content of 7.16%. This is less than one-half of the methoxyl content of the lignin from softwoods. The low methoxyl "lignin" is most abundant in the bark powder fraction. It appears that bark material insoluble in 72% sulphuric acid is a mixture of substances, some of which may contain little if any methoxyl groups (*5*).

Table I. Extractive Content of Douglas Fir Bark and Its Fractions[a]

(Quantities in per cent)

Extractive	*Whole bark ground to pass a 40-mesh sieve*	*Bark needles 40 to 60 mesh*	*Bark needles 60 to 80 mesh*	*Bark powder passing a 200-mesh sieve*	*Cork flakes*
Ethyl ether soluble	7.80	5.43	4.11	4.61	24.55
Ethanol soluble	13.97	9.69	9.62	24.31	9.22
Hot-water soluble	2.31	2.61	2.91	4.37	2.46
Total of three extractives	24.08	17.73	16.64	33.29	36.23

[a] Solubilities are reported on the moisture-free weight of unextracted materials.

Although the bark needle fraction appeared to be a ligno-cellulose substance, it was not practicable to isolate the cellulose by either the holocellulose or the Cross and Bevan procedures. It was found that the sodium sulphite solution could not be filtered after

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Table II. Analysis of Extractive-Free Douglas Fir Bark and Its Fractions[a]

(Quantities in per cent)

Constituent	Whole bark ground to pass a 40-mesh sieve	Bark needles 40 to 60 mesh	Bark needles 60 to 80 mesh	Bark powder passing a 200-mesh sieve	Cork flakes
Acetyl	0.83	2.39	3.67	0.41	.....
Ash	0.73	0.63	0.61	1.83	.....
Lignin	57.54	47.36	45.22	73.33	81.42
Methoxyl	3.76	3.89	3.86	2.55	.....
Pentosan	6.40	7.46	7.34	3.55	.....

[a] Percentages based on the moisture-free weight of extractive-free materials prepared according to TAPPI (T12m-45).

chlorination in the Cross and Bevan procedure, and washings with distilled water following the alcohol-ethanolamine extraction progressed very slowly in the holocellulose treatment. There appears, in addition, to be some loss of carbohydrate in the holocellulose procedure. After 13 treatments with chlorine gas and alcohol-ethanolamine solution, a gray "holocellulose" product (61.3% yield) was obtained from the 60- to 80-mesh needle fraction. This product, however, still retained 11.3% of material insoluble in 72% sulphuric acid. A white holocellulose product (19.75% yield) was obtained from the bark powder fraction. This product gave no insoluble residue with 72% sulphuric acid. "Lignin" and holocellulose from the powder fraction accounted for 93.0% of the extracted material; the cellulose in this fraction appears to be derived from broken needlelike elements of the bark.

An acetic acid content of 3.3 to 5.1% (acetyl group 2.39 to 3.67%) of the bark needles is indicated.

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Top Management and Engineering

Their Relationship in the Field of Paper Manufacturing

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To attain maximum efficiency in the development of a plant construction or process project, it is essential that top management and the engineering department work together very closely. Each has its responsibility one to the other. Management and sales inaugurate the basic development with the advice of engineering as to the feasibility of the project. The engineering department must draw up the plans considering possible alternatives in the event that it becomes necessary to deviate from the original, and submit them to management for approval. Careful consideration must be given to the sequence of the development so that the efficiency of the production will not be impaired to too great an extent. It is essential that the top management be kept informed at all times of the progress of the work so that it can effectively control the project. The engineering department should also be a source of trained personnel for the operating department, recognizing the fact that if capable men are to be held within an organization, they must be assured of promotion.

Engineering in paper mills branches into two main functions, preferably from the same root. The title of this paper specifies "in the field of paper manufacturing," and assumes that the enterprise is already an operating unit of one or more mills. That being accepted, the two functions can be designated by the headings: (1) development engineering, and (2) maintenance engineering.

No company manufacturing paper in a highly competitive market could continue to remain in a competitive position without both branches of engineering functioning effectively and efficiently. Quite probably they will both function under the same nominal head, whatever the title may be, but function they must.

However, because of the difference in the main objectives of the two the maintenance branch is unavoidably much more closely allied to actual production than the development branch, which is more closely connected to top management. Therefore, this paper is concerned mostly with development engineering branch, although to function properly, development, maintenance, and production must coordinate closely throughout.

The definition of "development engineering" might well then be termed the application of engineering principles in assisting top management to formulate a fairly definite development objective and the carrying out of the steps necessary to obtain this objective in a manner that will give the highest returns as soon as possible, within the expenditure approved by the management,

The paper industry in the United States and Canada appears to have reached a stage when new mill construction is declining and the emphasis is toward modernizing and expanding existing facilities as well as venturing into new fields. Because of the nature of the problems involved, a thorough knowledge of existing local conditions and practice is paramount. Therefore, the mill development branch must carry the major load whether outside help is required in

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some aspects or not although experts in any line are usually well worth their hire.

PLANT MODERNIZATION PROCEDURE

The procedure to adopt in the modernization of an existing mill or the revamping of any mill to produce a different end product is practically identical and should be according to the following sequence:

1. Policy. What is the objective as to quantity and quality?
2. General plan. Study and plan the most effective and desirable layout to obtain the desired over-all objective or objectives.
3. Sequence. What is the best sequence of the various development steps that will give the desired results with the highest return having due regard to possible interference with present production and ultimate plant requirements and layout.

Policy

A policy in regard to development is a prime necessity to enable an intelligent study to be made of future development. This study is carried out primarily by top management and sales. The sales department should advise as to the quality and the quantity over the period projected to complete the development. The production and engineering departments coordinate in arriving at satisfactory flow diagrams and equipment required to achieve the desired results. They affect policy chiefly when questions as to the feasibility of certain proposed changes are in doubt. This is necessary when alternative suggestions are made, and the method of obtaining the alternative product is a matter for production and engineering to study and give advice as to equipment changes and the approximate cost.

General Plan

With the policy outlined as to the projected sales requirements and the preliminary specifications of the production department requirements to meet the projected sales, the engineering department can then proceed with a general plan.

This general plan will be the result of many schematic drawings and requires a thorough knowledge of the over-all objective by everyone working on it. It must cover the entire operation from raw materials to the finished product as well as the requirements of auxiliary services such as steam, power, water, maintenance services, etc. The raw material and auxiliary services must keep step with the demand of the production department.

Thus each alternative in the over-all scheme of development requires a complete survey of all the requirements from the inception to the completion of the development scheme in all its various steps. The construction and operating problems must also be studied for each alternative, and layouts be made to obtain the best operating arrangement possible under each. This requires the closest type of cooperation between production and engineering with the top management as closely linked up with the trend of development as circumstances permit.

The general plan is then formulated, maintaining alternative ideas for future changes in the planned objective as much as is economically sound with provision for further expansion, if and when required.

The general plan is a big undertaking under any circumstances but can become an almost insurmountable obstacle unless alternatives are considered to avoid a complete revamping with every change in thought or market trend. As it is being developed, estimates of the comparative capital costs of each scheme, as well as the operating costs, must be made so that the final plan chosen will produce the required product at the lowest cost on its completion even though at times during the progress of the changeover or development costs may temporarily go up. It is the long-range picture that must be kept in mind, but management must be kept advised as to what the effect of the intermediate steps will be.

The results of these studies are submitted to top management for approval of some alternative or combination of alternatives, and the planning kept active throughout the development. The main features of the over-all picture, at least, must satisfy everyone concerned before any one step is actually carried out. This is a very important stage and requires considerable patience and perseverance.

This procedure insures that any project which is a part of the over-all scheme of development, or is at least a part of the accepted portion of the over-all scheme, will eventually became part of the whole. Some temporary work to link up with existing conditions will always be encountered in varying degrees. However, good planning and forethought should keep this to a minimum.

The provisions for further changes in the over-all plan cannot be overemphasized, and the layout should be kept as flexible as existing conditions permit.

The reason for the flexible layout is that with a general mill development in view, it is usually sound to expect that the whole scheme will not be completed within five or six years from the time of its inception. The industry changes so rapidly that changes in the ultimate should be anticipated and probable changes in the final requirements be kept in mind at all times. Space should be left wherever possible to provide for unforeseen contingencies. However, this provision for the future must be treated with a sound adjustment as it is easy to spend too much money for some unknown possibility which in all probability will never materialize. With a little ingenuity some provision can usually be made at relatively small expense and possibly only a revision in layout.

Development Sequence

When the general trend of development has been tentatively approved by the top management, an approximate schedule for the various projects in the over-all scheme must be laid out, fixing the priority of sequence of each step as far as is possible. This must be a very careful study as a change in one department may and usually does effect several other departments, such as steam, power, pulp supply, storage, and services. For a self-contained mill producing its own pulps, power, steam, and filtered water, the stepping up of the raw material and services to the paper machines may involve temporary overexpansion with re-

sultant high overhead unless very careful planning is resorted to in the sequence of the program. It may involve seeking a temporary supply of pulp from outside sources. This is a problem that must be solved with the closest possible coordination with the top management.

The sequence is also very definitely effected by the estimated returns that are anticipated in each step of the development. The projects giving the most desirable return, either profitwise or quality wise, deserve the first priority if they can be accomplished without interfering with the over-all objective too seriously.

Finally, before any final plan of procedure can be worked out, a definite method of financing the development is necessary. When the engineering department knows how much money it will be permitted to spend each year, a definite program can be outlined covering not only the sequence, but also the time for the completion of the over-all development.

The schedule for following through the entire development to its ultimate conclusion at a definite time will be the result of the studies outlined above. The financing controls the speed that the work can be done to such an extent that the top management must of necessity be thoroughly familiar with every move planned, when it will be done, and how much it will cost. This part of the scheme is where engineering and top management must work closely together.

With the time of completion of the job approximately fixed, the engineering staff necessary to satisfactorily detail the job must be obtained, and the construction and mechanical staff brought together at the right time to successfully carry through the various projects to their completion within the period allotted. Any deviation from the estimated time or cost of completion of any phase of the development must be reported to management immediately as soon as it becomes evident to give top management all the time possible for any readjustment that may be necessary.

If the planned development follows the schedule set, all the projects will link up as originally planned. The chances are that at the end of the initial program it will not be possible to recognize many parts of it, but if the contingencies have been provided for by arranging for probable further changes and expansion, it will still be possible to maintain and expand on the initial setup with satisfactory results.

All the points outlined above are very closely connected to the controlling reins of top management. Without top management's guiding hand, the development branch of engineering would be working at random purposes. It is the author's considered opinion that without the services of an efficient engineering development staff, the top management would find it most difficult to formulate sound policies for future guidance.

The procedure outlined above is desirable from an engineering standpoint and is followed fairly closely by the author's organization with one major exception, and that is the allocation of specific sums of money to be expended in the years during which the program is scheduled for completion. The reason is fairly obvious and is, first, that few companies have sufficient funds available to make specific plans for a definite expenditure for years in advance, and secondly, the priority of certain phases of the development change as the market changes.

In order to cope with this changing situation a complete list of work covering all improvements that might conceivably be undertaken with preliminary drawings and approximate estimates. These jobs are then tabulated by departments, giving a brief description of the job, the approximate cost, and a synopsis of the anticipated benefits to be derived for each item. This is all prepared before the new year in time for management to indicate what jobs may be included in the coming year's program. The indicated jobs are then made up in a more detailed tabulation and the sum total of the expenditures are the capital budget for that year when tentatively approved. By this arrangement, priorities are readjusted, and the expenditures kept to within the maximum amount considered advisable by the management.

On the approval of the capital budget each item therein is treated separately in greater detail and presented to the management for final approval. When final approval of any job is obtained, detail drawings, construction, and equipment installation is followed through to the satisfactory conclusion of the project. This system eliminates any possibility of the long range schedule of development getting out of line with immediate requirements, and keeps expenditure within the limits considered advisable for capital outlay for the year. Outage time for any equipment being changed is something to watch carefully, so as to prevent embarrassing sales any more than is absolutely necessary.

PERSONNEL TRAINING

A further function of the engineering staff is to supply partially trained personnel to the operating department. It has been substantially proved that a mechanical engineer working under the mill superintendent can readily make investigations of troublesome points and advise the engineering department as to what the trouble is in an engineering manner. It is still the responsibility of the engineering department to correct the situation but with a correct diagnosis this is not usually so difficult. The natural sequence is that these engineers will be rapidly promoted in the operating departments. It is definitely the responsibility of the engineering department to keep a few men suitable for such a move on their staff and thus be able to recommend their transfer whenever opportunity presents itself. This tends to build up a strong operating staff as well as being a great lift to the moral of the engineering staff. However, these transfers should be made within two or three years of joining the staff, as otherwise, a promising engineer will usually have a salary differential above that of the operating engineer unless transferred fairly quickly. It is difficult to part with the type of man required for this transfer, but this must be faced and provided for in selecting new personnel.

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Liner Boards from Jack Pine and Hardwood Semichemical Pulps

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Experiments at the U. S. Forest Products Laboratory indicate that liner board meeting commercial specifications and use requirements can be produced from jack pine neutral sulphite semichemical pulps and mixtures of jack pine and quaking aspen semichemical pulps made in yields near 80%.

The experimental jack pine and pine-aspen semichemical (78% yield) liner boards equaled commercial southern pine kraft liner board in bursting strength and were higher in tensile strength, but were appreciably lower in tearing strength and folding endurance.

Tests on corrugated container board made from the jack pine and pine-aspen liner boards and a straw corrugating medium, and on commercial kraft fiberboard, showed the semichemical boards to be higher in bursting strength, somewhat lower in tearing strength, and slightly lower in puncture and score-line resistance than the kraft fiberboard. The semichemical fiberboards held the same relation toward a jute container board except that the semichemical container board was higher in score-line resistance. Replacement of the straw by an aspen semichemical corrugating medium strengthened considerably the container board made from the jack pine-quaking aspen (50-50) semichemical liner boards, especially in puncture resistance.

Experimental liner boards made from quaking aspen, paper birch, eucalyptus, and a mixture of beech, cherry, and maple neutral sulphite semichemical pulps in yields of 70 to 80% approached commercial southern pine liner board in bursting strength, were equal or higher in tensile strength, were considerably lower in tearing strength and folding endurance, and had higher stiffness values.

Experimental liner boards made from jack pine sulphate semichemical pulps obtained in yields of 68 to 73% were somewhat below commercial kraft liner board in all strength properties.

Southern pine sulphate pulp was blended with the jack pine neutral sulphite semichemical pulp in test-sheet experiments. The substantial increase in tearing strength by the addition of only 25% of the kraft pulp indicated the possibilities of developing satisfactory blends containing large proportions of the semichemical pulp.

ALTHOUGH the making of corrugating board from high-yield semichemical pulp is well established, liner board is customarily made from kraft pulp produced in yields of only about 50% of the wood weight. In the present experiments the possibilities of making liner board from semichemical pulps were explored at the Forest Products Laboratory. An objective in these experiments was to determine the highest yield of jack pine semichemical pulp that would meet the requirements for liner board. Also aspen semichemical pulp was tried in mixtures with the jack pine pulps to determine whether appreciable quantities of this hardwood pulp could be used in such a combination. In addition, several other hardwood semichemical pulps were compared with the aspen semichemical pulp.

Within limitations imposed by the scope of these experiments the work included: (a) a comparison of the properties of jack pine sulphate and neutral sulphite pulps*—made in the yield range of approximately 50 to 80% and of neutral sulphite pulps made from quaking aspen, paper birch, a mixture of beech, cherry, and maple, and eucalyptus in the yield range of 70 to 80%; (b) a study of the effect of blending jack pine neutral sulphite semichemical and southern pine sulphate pulps; (c) a comparison of liner boards made from the various pulps with commercial southern kraft liner board; and (d) a comparison of jack pine and aspen semichemical corrugated container board with commercial kraft and jute container boards.

EXPERIMENTAL PART

Wood

The jack pine (*Pinus banksiana*) used in these experiments was obtained in two shipments. One (shipment 2515) was received from the region north of Lake Superior as slabs without bark from a sawmill operation and the other (shipment 2586) from northern Michigan as round wood from a pulpwood operation. The quaking aspen (*Populus tremuloides*) was obtained as pulpwood from Wisconsin (shipments 2483 and 2587). The paper birch (*Betula papyrifera*) was obtained from northern Michigan (shipment 2609). The American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), and maple (*Acer saccharum*) were cut in Pennsylvania and received with bark removed (shipment 2551). A mixture of equal parts of these woods was used for the experiments. The eucalyptus (*Eucalyptus gigantea*) was received as billets from Tasmania (shipment 2563).

All of these woods were converted into standard $^5/_8$-inch chips for the experiments.

Pulping

The digestions were made in equipment described elsewhere (*1*). Most of the digestions using neutral sulphite liquors (sodium sulphite plus sodium bicarbonate) were made in a stainless-steel-lined, steam-jacketed, tumbling digester with a capacity of 13 cubic feet. One digestion each of the jack pine, the aspen, and the beech-cherry-maple mixture was made

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* Acknowledgment is made to E. L. Keller and J. S. Martin of the Forest Products Laboratory staff, under whose supervision the neutral sulphite and sulphate pulping experiments, respectively, were made.

Table I. Neutral Sulphite Pulping Conditions and Yields of Pulp from Jack Pine, Slab Wood, and Several Hardwoods

Digestion No.	Impregnation conditions: Temperature, °C.	Impregnation conditions: Time at temperature hr.	Impregnating liquor: Sodium sulphite, g./l.	Impregnating liquor: Sodium bicarbonate, g./l.	Chemicals absorbed: Sodium sulphite, % of wood	Chemicals absorbed: Sodium bicarbonate, % of wood	Cooking conditions: Temperature, °C.	Cooking conditions: Time at temperature, hr.	Cooking conditions: Pressure, p.s.i.	Spent Liquor—sodium sulphite, g./l.	Total digestion time, hr.	Yield of pulp, %
					Jack Pine[a]							
5244	121	1.0	148.5	30.8	43.3	10.0	180	7.0	148	24.2	10.0	48.4
5241	121	1.0	141.3	34.4	35.5	8.4	170	10.2	120	24.0	13.2	62.1
5245	120	1.0	121.1	30.9	27.3	8.4	170	6.0	121	26.8	9.2	69.6
5242	121	1.0	100.0	25.0	19.9	5.6	170	3.0	117	25.7	6.2	77.4
5258	120	1.0	88.8	22.5	16.8	5.4	170	3.0	123	16.6	6.2	80.3
5259	120	1.0	89.7	22.9	17.0	4.7	170	4.0	124	13.7	7.2	75.8
5272	120	1.0	89.7	21.9	17.5	4.7	170	3.5	124	17.2	6.5	78.4
5315[b]	122	1.0	91.6	23.0	19.0	5.4	170	3.5	120	16.5	7.5	78.0[c]
					Aspen							
5263	120	1.0	59.9	23.7	9.6	6.9	170	0.75	139	11.6	3.8	77.5
5247	121	1.0	60.6	24.3	9.4	6.8	170	0.75	141	11.3	3.8	80.1
5310	122	1.0	61.2	23.6	10.7	7.0	170	0.60	120	10.1	4.3	78.0[c]
					Birch							
5328–29	121	1.0	81.0	34.5	10.2	8.6	170	1.40	134	11.2	4.3	78.6
					Beech-Cherry-Maple Mixture							
5285	122	1.5	151.0	53.1	18.3	10.7	170	2.2	110	9.2	6.7	72.0[c]
					Eucalyptus							
5296	120	1.5	120.5	28.8	12.0	7.8	170	2.5	140	4.1	5.9	70.7

[a] Slab wood except as noted. [b] Round wood used. [c] Estimated from digestion conditions used.

in a stainless-steel-lined stationary digester with a capacity of 225 cubic feet and equipped for circulation and external heating. The digestions employing the sulphite liquors (sodium hydroxide plus sodium sulphide) were made in a steel, steam-jacketed, tumbling digester with a capacity of 14 cubic feet.

The digestions with the neutral sulphite liquors were conducted as follows: The chips were steamed at atmospheric pressure for 0.5 hour. The steamed chips were then impregnated with the liquor at a temperature of 120°C. The excess liquor not absorbed by the chips was then removed and was later fortified for a subsequent digestion. The cooking was conducted with the chemicals left in the chips. The digestion conditions are given in Table I.

The digestions with the sulphate liquors followed a conventional, one-stage, alkaline pulping procedure. The digestion conditions are given in Table II.

Table II. Sulphate Pulping Conditions[a] and Yields of Pulp from Jack Pine Slab Wood

Digestion No.	Time at 170°C. hr.	Chemicals charged: Total concentration, g./l.	Chemicals charged: Sodium hydroxide, % of wood	Chemicals charged: Sodium sulphide, % of wood	Chemicals consumed, % of chemicals charged	Yield, %
2936	1.5	37.5	10.58	4.42	90.0	56.5
2954	1.5	34.38	9.69	4.06	91.2	61.4
2952	1.5	31.25	8.81	3.69	97.8	68.0
2953	1.0	25.0	7.05	2.95	99.1	70.7
2937	0.5	25 0	7.05	2.95	97.2	71.6
2939	0	25.0	7.05	2.95	94.4	73.3

[a] 1.5 hours from room temperature to maximum temperature of 170°C. for all digestions.

Table III. Strength Properties of Jack Pine and Hardwood Neutral Sulphite Pulps Used for Liner Board

Digestion No.	Yield, %	Bursting strength, Freeness, ml.[a]: 750 pt./lb./rm.[b]	Bursting strength, Freeness, ml.[a]: 550 pt./lb./rm.[b]	Tearing strength, Freeness, ml.[a]: 750 g./lb./rm.[b]	Tearing strength, Freeness, ml.[a]: 550 g./lb./rm.[b]	Tensile strength, Freeness, ml.[a]: 750 p.s.i.	Tensile strength, Freeness, ml.[a]: 550 p.s.i.	Folding endurance, Freeness, ml.[a]: 750 double folds	Folding endurance, Freeness, ml.[a]: 550 double folds
				Jack Pine[c]					
5244	48.4	1.22	1.41	1.37	1.15	8300	9,600	1250	1900
5241	62.1	1.22	1.44	1.60	1.25	8300	10,200	580	720
5245	69.6	1.15	1.30	1.40	1.20	6800	7,900	480	780
5242	77.4	0.84	1.08	1.35	0.95	6000	7,000	300	180
5258–59	78.4	0.97	1.07	1.09	0.90	4900	6,900	350	550
5315[a]	78.0	0.93	1.08	1.15	0.95	5000	7,300	250	480
				Aspen					
5247	80.1	0.46	0.72	1.09	0.97	2700	5,600	60	340
5310	78.0	0.52	0.75	0.95	0.83	3350	6,450	25	175
				Birch					
5328–29	78.6	..	0.92	..	0.90	..	7,000	..	320
				Beech-Cherry-Maple					
5285	72.0	0.49	0.58	0.93	0.98	3650	4,500	18	35
				Eucalyptus					
5296	70.7	0.49	0.54	1.09	1.18	2730	3,200	14	20

[a] Schopper-Riegler. [b] 25 × 40—500 [c] Slab wood used for jack pine digestions except 5315 for which round wood was used.

Table IV. Strength Properties of Jack Pine Slab Wood Sulphate Pulps Used for Liner Board

Digestion No.	Yield, %	Bursting strength, Freeness, ml.[a] 750 pt./lb./rm.[b]	Bursting strength, Freeness, ml.[a] 550 pt./lb./rm.[b]	Tearing strength, Freeness, ml.[a] 750 g./lb./rm.[b]	Tearing strength, Freeness, ml.[a] 550 g./lb./rm.[b]	Tensile strength, Freeness, ml.[a] 750 p.s.i.	Tensile strength, Freeness, ml.[a] 550 p.s.i.	Folding endurance, Freeness, ml.[a] 750 double folds	Folding endurance, Freeness, ml.[a] 550 double folds
2946	56.5	1.32	1.44	1.60	1.55	9000	9600	1450	2000
2952	61.4	1.35	1.43	1.60	1.35	7000	9000	1050	1520
2952	68.0	0.82	1.08	1.60	1.25	3600	5800	350	660
2935	70.7	0.79	0.95	1.25	0.85	6200	9100	460	790
2937	71.6	0.60	0.85	1.90	1.35	2700	4600	180	370
2939	73.3	0.70	0.86	1.60	1.20	2900	4400	200	890

[a] Schopper-Riegler. [b] 25 × 40—500.

Upon completion of the digestions the chips, pulped to a greater or lesser degree according to the conditions, were discharged at atmospheric pressure.

Fiberizing and Processing

All of the partially or fully pulped chips were fiberized in a commercial-sized disk mill. The jack pine neutral sulphite and sulphate pulps were also processed slightly in a 50-pound beater, as a means of control of the final pulp properties, except for the two lowest-yield neutral sulphite pulps (Nos. 5244 and 5241, Table I). The highest-yield sulphate pulp (No. 2939, Table II) was also jordaned lightly after beater processing. The hardwood pulps were run into liner board without beater or jordan processing. The fiberized pulps from the disk mill were tested for strength by the TAPPI standard beater procedure. The results of the strength tests are given in Tables III and IV.

Paperboard Making

All of the pulps were made into 16-point liner on a 12-inch experimental fourdrinier paper machine operated at a speed of 25 feet per minute. Liner boards were also made on this machine from several mixtures of the jack pine and aspen neutral sulphite semichemical pulps made in yields near 78%. The pulps were run without any added material. In addition to the experimental liner boards made at the Laboratory, runs were made elsewhere on a 60-inch fourdrinier machine operated at a speed of 50 feet per minute using Forest Products Laboratory prepared

Table V. Strengths of Jack Pine Neutral Sulphite and Commercial Southern Pine Kraft Liner Boards

Machine run No.	Type of wood	Pulp yield, %	Properties of liner boards: Weight, lb. per 1000 sq. ft.[a]	Caliper, 0.001 in.	Density, g./cc.	Bursting strength, Mullen, lb.	Bursting strength, Unit, pt./lb./rm.[a]	Tearing strength, g./lb./rm.[a]	Tensile strength p.s.i.	Folding endurance double folds	Compression resistance lb.
					Jack Pine Neutral Sulphite						
2284	Slab wood	48.4	55.3	17.4	0.61	116	0.60	3.15	5105	1773	24.6
2822	Slab wood	62.1	64.8	15.5	0.80	148	0.66	2.47	6695	1876	54.7
2885	Slab wood	69.6	56.0	16.1	0.66	150	0.77	2.45	6350	648	31.2
2883	Slab wood	77.4	57.7	16.9	0.66	170	0.84	2.27	6935	473	37.8
2915	Slab wood	78.4	45.0	16.0	0.54	126	0.81	2.29	4255	510	..
2943	Round wood	78.0	46.3	15.8	0.56	110	0.69	2.07	3699	477	..
2603[b]	Round wood	78.0	42.9	13.5	0.61	103	0.66	1.87	4935	425	..
					Commercial Southern Pine Kraft						
..	Round wood	42.9	42.9	14.5	0.58	110	0.73	3.26	4450	1310	27.2

[a] 25 × 40—500. [b] Shipment number.

Table VI. Properties of Liner Boards Made with Various Combinations of Jack Pine and Aspen Semichemical Pulp Compared with Commercial Southern Pine Kraft Liner Boards

Machine run No.	Pulp furnished: Jack pine, %	Pulp furnished: Aspen, %	Type of Wood	Pulp yield, %	Properties of Liner Boards: Weight lb. per 1000 sq. ft.	Caliper, 0.001 in.	Density, g./cc.	Bursting strength, Mullen, lb.	Bursting strength, Unit, pt./lb./rm.[a]	Tearing strength, g./lb./rm.[a]	Tensile strength, p.s.i.	Folding endurance, double folds	Compression resistance, lb.
					Jack Pine and Aspen Semichemical								
2943	100	0	Round wood	78.0	46.3	15.8	0.56	110	0.69	2.07	3699	477	..
2947	85	15	Round wood	78.0	46.9	15.7	0.57	121	0.74	1.72	4765	233	...
2946	70	30	Round wood	78.0	48.1	17.0	0.54	124	0.74	2.06	4535	296	..
2944	50	50	Round wood	78.0	52.6	14.7	0.69	119	0.65	1.75	4988	471	..
2945	0	100	Round wood	78.0	53.6	14.6	0.71	116	0.63	1.31	5550	107	..
2914	50	50	Slab wood	78.4	49.0	13.7	0.68	118	0.69	1.94	5410	333	26.4
2602[b]	50	50	Round wood	78.0	47.9	13.1	0.66	131	0.77	1.48	6135	416	..
					Commercial Southern Pine Kraft								
..	..	..	.....	..	42.9	14.5	0.58	110	0.73	3.26	4450	1310	27.2

[a] 25 × 40—500. [b] Shipment number.

jack pine neutral sulphite pulp (No. 5315) and a 50-50 mixture of this pulp and the aspen neutral sulphite pulp (No. 5310). The results of strength tests on the boards are given in Tables V, VI, VII, and VIII. The average results of tests on commercial southern pine kraft liners from five sources are also given in these tables.

duced in 77.4% yield (No. 5242, Table I) and a southern pine sulphate pulp made previously at the Forest Products Laboratory (digestion No. 2899). The sulphate pulp was processed in a Valley test beater to a freeness of 745 ml.* for use in the test sheets. The semichemical pulp was not processed beyond fiberizing. The strength data for the test

Table VII. Properties of Jack Pine Sulphate and Commercial Southern Pine Kraft Liner Boards

Machine run No.	Pulp yield, %	Properties of liner boards: Weight, lb. per 1000 sq. ft.	Caliper, 0.001 in.	Density, g./cc.	Bursting strength: Mullen, lb.	Bursting strength: Unit, pt./lb./-rm.[a]	Tearing strength, g/lb./-rm.[a]	Tensile strength, p.s.i.	Folding endurance, double folds	Compression resistance, lb.
				Jack Pine Slab Wood						
2888	56.5	50.0	15.2	0.63	146	0.84	3.71	4810	3440	22.1
2951	61.4	48.3	16.0	0.58	103	0.61	3.68	3725	1692	..
2926	68.0	46.3	14.0	0.64	93	0.57	2.63	3650	1178	21.0
2886	70.7	51.0	18.3	0.54	80	0.45	2.92	2772	810	15.3
2889	71.1	49.3	16.3	0.58	71	0.41	2.66	3140	1023	..
2894	73.3	46.3	16.5	0.54	76	0.47	2.97	2984	704	17.0
2895[b]	73.3	43.4	15.4	0.54	87	0.58	2.61	3250	601	19.8
				Commercial Southern Pine Kraft						
..	..	42.9	14.5	0.58	110	0.73	3.26	4450	1310	27.2

[a] 25 × 40—500. [b] Pulp for this run was given a light Jordan processing.

A corrugating board was made on the 60-inch four-drinier machine from aspen semichemical pulp (No. 5310). The results of strength tests are given in Table VIII (No. 2604) in comparison with a commercial straw board.

Container Board Testing

Container boards fabricated from the liner boards made on the small commercial paper machine were tested for bursting strength, tearing strength, impact resistance using the Beach puncture tester, and score-line strength using the Carlson score tester (*2*). The results of these tests are given in Table IX.

Blending Experiments

Test sheets were made from various mixtures of the jack pine neutral sulphate semichemical pulp pro-

sheets are given in Table X, and curves relating strength and pulp composition in Fig. 1.

DISCUSSION

Pulping

The neutral sulphite pulping of jack pine required large amounts of chemicals and relatively long digestion times at 170°C. The total of chemicals con-

Table VIII. Properties of Liner and Corrugating Boards Made from Hardwood Neutral Sulphite Semichemical Pulps Compared with Commercial Liner and Corrugating Boards

Machine run No.	Species	Pulp yield, %	Properties of boards: Weight, lb. per 1000 sq. ft.	Caliper, 0.001 in.	Density, g./cc.	Bursting strength: Mullen, lb.	Bursting strength: Unit, pt./lb./-rm.[a]	Tearing strength, p.s.i.	Tensile strength, p.s.i.	Folding endurance, double folds	Compression resistance, lb.
					Hardwood Liner Boards						
2945	Aspen	78.0	53.6	14.6	0.71	116	0.63	1.31	5550	107	..
2913	Aspen	78.4	61.0	14.8	0.79	127	0.64	1.35	6280	141	48.2
2962	Paper birch	78.6	54.4	15.3	0.68	134	0.71	1.28	5270	58	45.7
2927	Beech-maple-cherry	72.0	52.3	15.1	0.66	102	0.57	1.16	4660	41	34.9
2917	Eucalyptus	70.7	46.4	14.8	0.60	111	0.69	1.28	5065	127	37.9
					Commercial Southern Kraft Liner Board						
..	.....	..	42.9	14.5	0.58	110	0.73	3.26	4450	1310	27.2
					Corrugating Boards						
2604[b]	Aspen	78.0	32.6	8.1	0.77	101	0.88	0.99	7740	576	24.2
2540[b]	Straw	..	34.0	11.0	0.59	22	0.20	0.97	1560	15	10.0

[a] 25 × 40—500. [b] Shipment number.

sumed varied from 22.0% for the highest yield to 58.3% for the lowest yield; the pulping time varied from 3 to 14 hours, respectively. The relatively high chemical consumption is characteristic of soft-

* Freeness values given in this report were determined on the Schopper-Riegler instrument.

woods when pulped by a neutral process. In comparison with the highly alkaline sulphate pulping of this species, the neutral sulphite required approximately 45% more of chemicals in terms of sodium oxide and much longer time to produce pulps in the same yield (Tables I and II).

strength. The pulp made in 78% yield from round wood had practically the same strength as that from slab wood.

Jack Pine Sulphate Pulps. The jack pine sulphate pulps also varied in strength with increase in yield (Table IV). The strength data at a freeness value

Table IX. Strength Properties of Semichemical Fiberboards Compared with Commercial Kraft and Jute Fiberboards

Fiberboard		Basis weight, lb. per 1000 sq. ft.	Bursting strength, lb.	Tearing strength, Direction		Puncture test Beech units	Score strength, Bar score, Direction		Score strength, Rotary score, Direction	
Liners	Corrugating medium			In machine, g.	Across machine, g.		In machine, Carlson units	Across machine, Carlson units	In machine, Carlson units	Across machine, Carlson units
			Semichemical							
Jack pine semichemical	Straw	134	283	1730	1210	140	20.9	19.2	24.6	17.5
50-50 jack pine-aspen semichemical	Straw	140	269	1340	1470	156	15.7	15.2	16.7	11.1
50-50 jack pine-aspen semichemical	Aspen semichemical	144	250	1730	1870	221	19.4	21.4	15.2	16.2
			Commerical							
Kraft	Straw	131	206	1890	1990	170	14.4	21.7	21.7	23.3
Jute	Straw	166	211	1800	1890	181	16.5	13.5	20.1	12.3
Jute	Straw	174	181	1760	1460	..	19.7	12.5	18.5	12.0

Considerably less of chemicals and shorter digestion times were required for the neutral sulphite pulping of the several hardwoods in comparison with the jack pine, mainly because of the lower lignin contents of the hardwoods (Table I). Among these hardwoods the aspen was somewhat more readily pulped than the others.

Strength Properties of the Pulps

Jack Pine Neutral Sulphite Pulps. The jack pine neutral sulphite pulps showed certain variations in strength with increase in pulp yield from 48 to about 80% (Table III). The strength data at a freeness value of 750 ml. were plotted against yield and the resultant curves are presented in Fig. 2. The pulps appeared to show maximums in bursting, tearing, and tensile strengths at pulp yields of 55 to 60%. The

Table X. Strength Data for Test Sheets from Jack Pine Semichemical and Southern Pine Sulphate Pulps and Mixtures Thereof

Proportion of pulps in mixture					
Jack pine semichemical, %	100	85	70	50	0
Southern pine sulphate, %	0	15	30	50	100
Properties of pulp mixture					
Bursting strength, pt./lb./rm.[a]	0.56	0.72	0.59	0.95	1.04
Tearing strength, g./lb./rm.[a]	1.66	1.85	1.86	1.98	2.07
Tensile strength, p.s.i.	2880	3410	4010	6100	9100
Folding strength, double folds	181	287	366	478	892
Freeness (Schopper-Riegler), ml.	825	815	790	775	745

[a] 25 × 40—500.

decrease in these pulp strengths from the maximum strengths with further increase in yield to the highest value of 78%, however, was moderate, 25 to 30%. The folding endurance, on the other hand, was highest for the pulp of lowest yield, in which case it was about three times as high as for the pulp of highest yield. The strongest pulps approached sulphate pulp in

of 750 ml. were likewise plotted against yield and the curves may be found in Fig. 2. The bursting and tearing strengths and folding endurance values for the pulp of highest yield were 40 to 80% lower than for the pulp of lowest yield. Tearing strength, however, appeared to change little with yield. At the lowest yields the sulphate pulps were somewhat stronger than the neutral sulphite pulp. At yields over 70%, however, the neutral sulphite pulps were appreciably stronger than the sulphate pulps, except in tearing strength. Characteristically, the chemical consumption on a sodium oxide basis was considerably lower, 55%, and the pulping time much shorter for the strongly alkaline sulphite digestions than for the neutral sulphite digestions.

Hardwood Neutral Sulphite Semichemical Pulps. The several hardwood neutral sulphite semichemical pulps varied in strength among themselves as well as having different strength properties than the jack pine semichemical pulps described previously (Table III). The birch semichemical pulp was slightly higher in bursting and tensile strength than the aspen semichemical pulp, and both had approximately the same folding endurance. Both pulps were appreciably higher in these properties than the semichemical pulps made from the beech-cherry-maple mixture and from the eucalyptus. The tearing strengths of the several hardwood pulps were not greatly different, with a possible slight advantage for the eucalyptus pulp. Since the aspen and birch pulps were made in a yield of 78% in comparison with approximately 70% for the others, the particular strength advantages indicated for the aspen and birch pulps would be even greater if the comparisons were made at the same yield. Compared to the jack pine neutral sulphite semichemical pulp produced in the same yield, the aspen and birch semichemical pulps were, on the other hand, appreciably lower in bursting strength, equal or slightly lower in tearing and tensile strengths,

and generally lower in folding endurance, especially at the higher freeness value.

FIBERIZING AND PROCESSING

The chips from the various digestions were fiberized under conditions established by trial to give pulps with a minimum of shives, a freeness high enough for

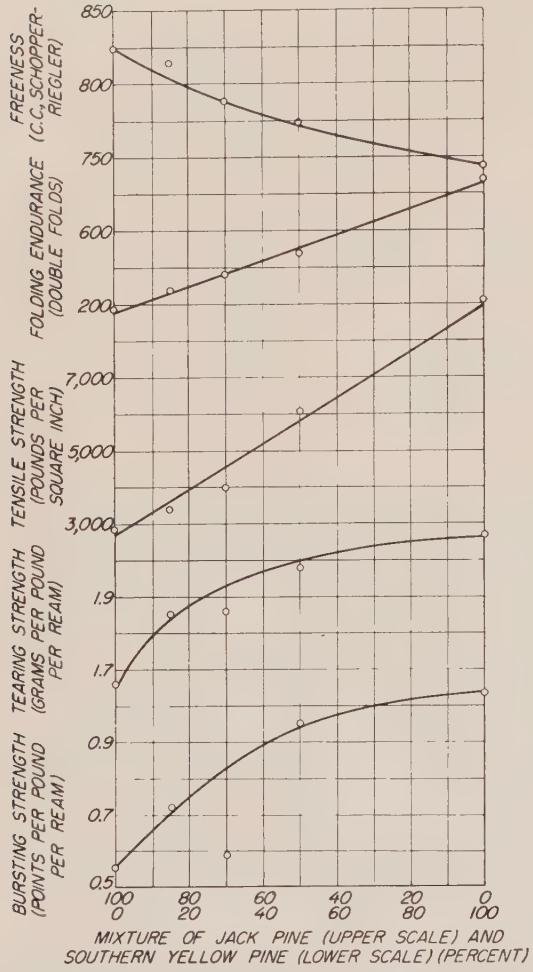
FREENESS (C.C. SCHOPPER-RIEGLER)
FOLDING ENDURANCE (DOUBLE FOLDS)
TENSILE STRENGTH (POUNDS PER SQUARE INCH)
TEARING STRENGTH (GRAMS PER POUND PER REAM)
BURSTING STRENGTH (POINTS PER POUND PER REAM)
MIXTURE OF JACK PINE (UPPER SCALE) AND SOUTHERN YELLOW PINE (LOWER SCALE) (PERCENT)

Fig. 1. Strength properties of test sheets prepared from mixtures of various proportions of jack pine semichemical and southern pine sulphate pulps

satisfactory paper-machine operation, and an optimum combination of bursting and tearing strengths as determined on test sheets. Jack pine neutral sulphite pulps made in yields of over 70%, when fiberized to a freeness value of 700 ml., were too slow-draining for satisfactory operation of the paper machine. On the other hand, pulps fiberized to a freeness value of 915 ml. although satisfactorily free from shives, were low in bursting strength and high in tearing strength. Finally, pulps fiberized to a freeness of 850 to 875 ml. had a relatively high bursting strength and a moderately high tearing strength and represented the best combination of the pulp properties and characteristics mentioned previously.

When the fiberized pulp with a freeness value of 915 ml. was processed further in the 50-pound beater in attempting to increase the bursting strength, the tearing strength dropped to a very low value before a satisfactory bursting strength was developed. When this same pulp was processed in a test beater, however, a favorable combination of bursting and tearing strength was obtained. Further, when this free pulp was passed through the disk fiberizer a second time, a favorable combination of bursting and tearing strengths was obtained. These brief fiberizing and processing experiments indicate that there is a rather narrow latitude of processing conditions for attainment of optimum properties in the jack pine neutral sulphite semichemical pulps and that these pulps may be sensitive toward the type of processing employed.

Energy consumption data were obtained for fiberizing the jack pine neutral sulphite pulps made in yields near 78% under conditions that gave the

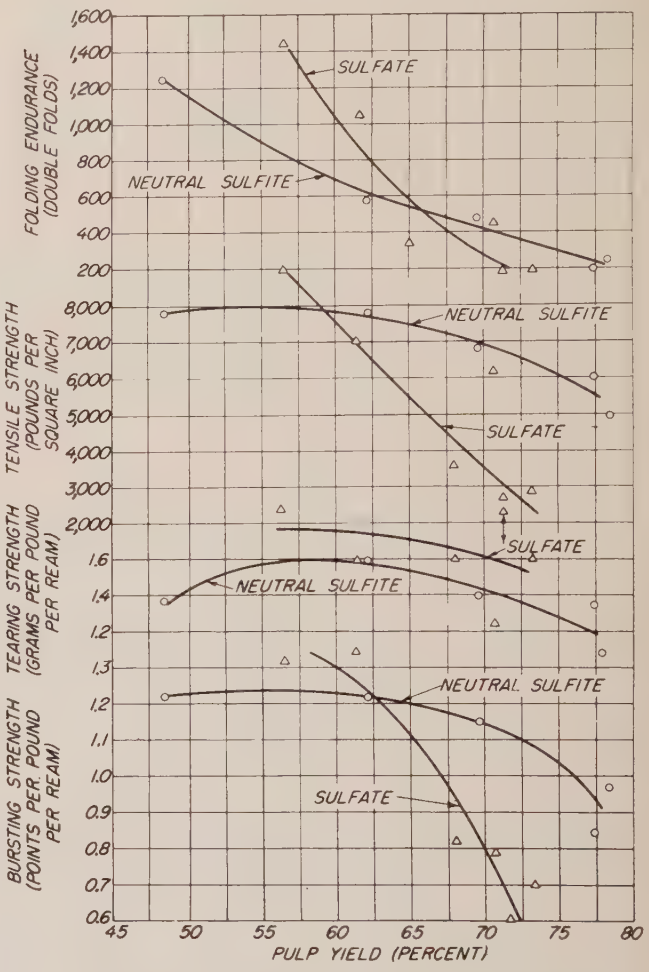
FOLDING ENDURANCE (DOUBLE FOLDS)
SULFATE
NEUTRAL SULFITE
TENSILE STRENGTH (POUNDS PER SQUARE INCH)
TEARING STRENGTH (GRAMS PER POUND PER REAM)
BURSTING STRENGTH (POINTS PER POUND PER REAM)
PULP YIELD (PERCENT)

Fig. 2. Influence of the degree of pulping in terms of yield of pulp on the strength properties of jack pine neutral sulphite and southern pine sulphate semichemical pulps

optimum combination of strength and freeness. The values obtained were 43 to 45 hp.-days per ton. The aspen semichemical pulps required 20 to 25 hp.-days per ton.

Liner Board Experiments

Jack Pine Neutral Sulphite Liner Boards. The liner boards from the jack pine neutral sulphite pulps made in yields of 48 to 78% from the slab wood showed a considerable range in strengths (Table V). When

the strength properties of the liner boards are considered in view of the freeness values and degrees of processing of the respective pulps, the relationship of board strength to yield is similar to that indicated by the pulp strength tests. For example, the pulp of lowest yield was used unprocessed, whereas the pulps of highest yield were processed to a certain extent in the disk fiberizer and additionally in the beater. The relatively high tensile strength and compressive resistance of No. 2882, Table V, and low strengths of No. 2915 with respect to yields were partly due to the respective high and low densities of the liner boards.

The liner board made from the pulp from the round wood (No. 2943, Table V) was definitely weaker than those made from the slab wood (Nos. 2883 and 2915, Table V), although the pulp strengths, as judged from the TAPPI beater test, were practically the same (Table III). The relatively low strength of the board from the round wood was possibly due to underprocessing the pulp in the disk fiberizer and consequently the inability to attain the optimum bursting and tearing strengths in the beater, as discussed previously.

Although the presence of pitch in the pulps from both slab and round wood was quite pronounced during the fiberizing operation, no difficulties from this source were encountered on the paper machine.

The liner boards made from the jack pine neutral sulphite pulps produced in yields near 78%, which were of particular interest in these experiments, varied considerably in their strength properties (Nos. 2883, 2915, 2943, and 2603, Table V), but their average was equal to or higher than the commercial kraft board average in bursting and tensile strength and compressive resistance, was definitely lower in tearing strength, and was decidedly lower in folding endurance (Table V). In other words, the jack pine neutral sulphite semichemical boards were as stiff or stiffer, but less resilient, than the kraft boards.

The experimental liner board made from lowest yield jack pine neutral sulphite pulp (No. 2884, Table V) was somewhat lower in bursting strength than the commercial kraft board, but it was equal or superior in other strength properties. If this pulp had been processed slightly, the board made from it would undoubtedly have been equal or superior to the commercial kraft board in all the strength properties tested.

Jack Pine-Aspen Neutral Sulphite Semichemical Boards. The experimental liner boards made on the 12-inch machine from several aspen-jack pine neutral sulphite semichemical pulp mixtures containing up to 50% of the aspen pulp did not differ greatly in strength properties from the 100% jack pine board (Nos. 2943, 2947, 2946, and 2944, Table VI). The bursting strengths of the aspen-jack pine boards were the same or slightly higher, the tearing strengths somewhat lower, the tensile strengths increasingly higher with increase in the amount of aspen pulp, and the folding endurances were generally somewhat lower than for the all jack pine board. The liner board made from the 100% aspen pulp in comparison with the 100% jack pine liner board had a slightly lower bursting strength, an appreciably lower tearing strength, a higher tensile strength, and a much lower folding endurance. Thus the properties of the boards from the pulp mixtures had properties generally commensurate with the proportions of aspen and jack pine pulps present although the tearing strengths and folding endurance of the boards containing 15 and 30% of the aspen pulp were somewhat lower than expected.

The liner board made on the 60-inch paper machine from the 50-50 aspen-jack pine neutral sulphite semichemical pulps (No. 2602, Table VI) had appreciably higher bursting and tensile strengths, a somewhat lower tearing strength, and the same folding endurance as the board made on the 12-inch paper machine from the same pulps. These differences in strength can be attributed to differences in processing of the pulps.

In comparison with the average results for the commercial kraft boards (Table VI), the tests on the liner board made on the larger of the two machines (No. 2602, Table VI), from the 50-50 mixture of jack pine and aspen semichemical pulps, showed the semichemical board to have the same bursting strength and a higher tensile strength, but a lower tearing strength by 50% and a lower folding endurance by 75%. The neutral sulphite semichemical board again tended to be less resilient than the kraft board.

Jack Pine Sulphate Boards. The liner board made on the 12-inch paper machine from the sulphate pulp produced in 56.5% yield (No. 2888, Table VII) was exceptionally strong in all respects, except possibly for an ordinary value for compression resistance. All the strength values except compression resistance were higher for this board than for the commercial kraft board (Table VII) used for comparison. However, as the yield of pulp was increased, there was a general decrease in strength. The boards from the pulps made in yields of about 70% were significantly lower in all strength properties than the commercial board. In the case of the pulp of highest yield, an increase in bursting strength at the expense of tearing strength was obtained by a light jordan processing of the pulp following a light beater processing, although the bursting strength was not raised to that of the commercial boards (No. 2895, Table VII).

In comparison with the jack pine neutral sulphite semichemical boards the sulphate semichemical boards were higher in tearing strength and folding endurance, but lower in bursting and tensile strengths and compression resistance.

Hardwood Neutral Sulphite Semichemical Liner Boards. The liner boards made on the 12-inch paper machine from the hardwood neutral sulphite semichemical pulps approached the commercial kraft liner board in bursting strength, were somewhat higher in tensile strength and appreciably higher in compressive resistance, but were much lower in tearing strength and folding endurance (Table VIII). The hardwood boards tended to be somewhat more dense than the softwood boards. In general it would be expected that fiberboard boxes made with the hardwood liner boards would have excellent stiffness but be lacking somewhat in resilience or impact resistance.

Among the hardwoods themselves the aspen and birch semichemical liner boards (Nos. 2945, 2913,

and 2962, Table VIII) were generally slightly stronger than the boards made from the beech-cherry-maple mixture (No. 2927) and the eucalyptus semichemical pulps (No. 2917) even though the latter were produced in appreciably lower yields. The strengths of the hardwood liner board appeared to be in agreement with the respective pulp strengths (Table III) when freeness and processing differences were considered.

Tests on Container Board

Jack pine and jack pine-aspen neutral sulphite semichemical liner boards made on the 60-inch paper machine were combined with both commercial 9-point strawboard and experimental 9-point aspen semichemical board on a commercial corrugating and combining machine. The properties of the aspen corrugating board are given in Table VIII in comparison with a commercial straw corrugating board. The aspen corrugating board was considerably stronger than the straw board in all respects, except tearing strength, which was the same.

The container boards made with the semichemical liner boards had appreciably higher bursting strength than the commercial kraft or jute corrugated fiberboard, Table IX.

Tearing-strength tests showed that the kraft container board was the highest in this respect, followed fairly closely by the jack pine-aspen semichemical container board with aspen semichemical corrugations and one of the jute container boards. The semichemical fiberboards with the straw corrugations had tear-strengths about 25% less than the kraft fiberboard.

The jack pine and jack pine-aspen container boards with the straw corrugations gave puncture-test values somewhat below those for the commercial kraft and jute container boards. The jack pine-aspen container board with the aspen semichemical corrugating medium, on the other hand, was higher than the commercial container boards.

Results of tests of the strength of the various container boards at the score line are available for both bar and rotary type of scores in and across the machine direction of the container boards. Though there are several apparent discrepancies in these data, it appears that the following over-all rating of the container boards can be made for strengths at the score line. The kraft container board was superior to the others, followed closely by the jack pine semichemical container board, and with the jack pine-aspen container board with the aspen semichemical corrugation being third. The jack pine-aspen container board with straw corrugations was similar to the jute container boards. Since fiberboard boxes show score-line failures in service more often than other failures, a satisfactory score-line test of the fiberboard should give some indication of the serviceability of the fiberboard as a box. Further, score-line failures most often occur in the horizontal end scores, although this depends on the size and shape of the box. The horizontal score is a rotary score in the cross machine direction. Comparing the different container boards for strengths at this particular score line, the same rating is found to hold generally.

The results of the various tests on the container boards appeared to be fairly consistent with the respective qualities of the liners and corrugations used. From an over-all standpoint it seems possible that the jack-pine and aspen container boards made from high-yield neutral sulphite pulps would make serviceable corrugated fiberboard boxes. In general, the neutral sulphite boxes would be expected to be somewhat lower in serviceability than kraft boxes, but possibly equal or superior to jute boxes. However, box tests would be needed to prove these points. The upgrading of the jack pine-aspen container board by the use of the aspen semichemical corrugation in place of the strawboard, as well as the relatively good showing of the semichemical board containing 50% each of aspen and jack pine semichemical pulps, was noteworthy. The generally favorable results from the semichemical container boards in comparison with the commercial container boards were likewise interesting in view of the relatively low tearing strengths and folding endurances of the semichemical liner boards.

Blending Experiments

The southern pine sulphate pulp used in the blending experiments had been processed to a slightly lower freeness value than desired and was considerably stronger than the higher-freeness jack pine semichemical pulp, which was used unbeaten. The differences in bursting and tensile strengths and folding endurance were not so great, although still considerable, when the two pulps were compared at the same freeness value.

When the jack pine semichemical and southern pine sulphate pulps were blended in various proportions (Table X and Fig. 1), there was an increase in strength and decrease in freeness as the proportion of southern pine pulps in the mixture was increased. With successive increases in proportion of southern pine pulp, the bursting and tearing strengths tended to level off toward maximum values near a 50-50 mixture, whereas tensile strength and folding endurance continued to increase in a more linear manner. About 50% of the total increase in bursting and tearing strengths in proceeding from all jack pine semichemical to all southern pine sulphate pulps was obtained when only 25% of the southern pine pulp was present in the mixture. If this fact should hold for liner board made from commercial pulps, then there is a possibility that a substantial increase in strength (especially tearing strength, which tends to be low in the jack pine neutral sulphate semichemical pulps) could be realized by blending in a relatively small amount of southern pine sulphate pulp.

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The Nature of the Color Changes in Groundwood

J. A. VAN DEN AKKER, HARRY F. LEWIS, GARY W. JONES, and M. A. BUCHANAN

This paper discusses the color of groundwood, the action of light on the color, and the nature of the color change resulting from sodium peroxide bleaching. The characteristic downward course of the "color curve" in the blue and violet regions of the spectrum, which accounts for the yellowness of groundwood, continues in the ultraviolet region with the curve gradually levelling off at a reflectivity of only about 8% for wavelengths below 280 mmu. This behavior of the complete spectral reflectivity curve, coupled with the known spectral absorption of lignin, suggests that lignin is primarily responsible for the yellowish color of groundwood pulp. The change in color produced by light, which is most effectively measured in technical studies through brightness (papermakers'), is strongly nonlinear with time of exposure, the rate of change being very great for short exposure. The influence of the groundwood content in mixed furnishes, both on the color and color changes, is disproportionately large for small groundwood content. The pH of the furnish is very important, the optimum value with regard to high brightness before and after fading being about 4.0. Oxygen plays only a minor role in the primary reactions of fading. Moisture content has a small but definite effect. Temperature alone causes only inappreciable darkening of color, but elevation of temperature during exposure to light greatly increases the fading. The spectral sensitivity of groundwood indicates strongly that lignin is mainly responsible for the yellowing and darkening of color produced by light. The characteristic change of color is produced by ultraviolet light; light of wavelength longer than 480 mmu has a small bleaching action, and the nature of fading produced by light of only moderately short wavelength is of a character different from that of ordinary fading by ultraviolet light; there are at least two photochemical reactions involved in fading of groundwood. It seems probable that one of the effects of ultraviolet light is to disrupt certain linkages in the materials of the pulp which permits subsequent oxidation. Long exposures of groundwood to sunlight and the radiation from a Fade-Ometer arc produce changes in the measurable chemical characteristics of the pulp. These changes support the view that lignin is responsible for the fading effect, although the state of chemical knowledge is not sufficiently well advanced to permit definite conclusions on the relationship between the color changes and the chemical changes. Recent work on the effect of sodium peroxide bleaching on groundwood quite definitely indicates that the bleaching mainly affects the total lignin in the pulp; that the bleaching action on that portion of the lignin which is extractable (native lignin) is the same as that on the total lignin; and that, in spite of large consumption of the peroxide by the nonlignin components, virtually none of the observed bleaching action is attributable to the latter.

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THE layman probably fails to appreciate the economic advantages and the meritorious properties of groundwood papers that are so apparent to newspaper publishers, producers of catalogs, and to other consumers requiring an inexpensive paper having high ink receptivity and good opacity. Without doubt, his judgment of such papers is strongly influenced by the inferior color and color stability of groundwood. These rather conspicuous shortcomings of groundwood have been studied in a number of investigations over a period of more than fifty years and, because the general problem of color of groundwood has proved to be a difficult one, our present knowledge of the subject is still incomplete and inexact. However, recent studies have contributed significantly to the chemistry and physics of the groundwood color problem, and it is hoped that a review of these contributions, together with new information on the physical aspects of the bleaching of groundwood, will stimulate others to do further work in this field.

The literature on researches in the field prior to the studies conducted at The Institute of Paper Chemistry (*1–5*) under the sponsorship of the Groundwood Paper Manufacturers Association has been presented and discussed in a paper by Lewis, Reineck, and Fronmuller (*1*).

THE COLOR OF GROUNDWOOD

Undyed papers containing a substantial percentage of groundwood pulp typically have a color that might be described as a very light yellowish gray. The spectral reflectivity curve ("color curve") for a 100% groundwood sheet, obtained with a General Electric recording spectrophotometer, is presented in Fig. 1.* The only characteristic feature of this curve is its sharp drop in the wavelength range just above 400 mmu. This feature distinguishes the color curve of groundwood from that of any of the chemical pulps and, of course, accounts for the yellow hue of groundwood. When special equipment is employed for the extension of the spectral reflectivity measurements into the ultraviolet region (*6*), it is found that the downward course of the curve continues almost linearly to a wavelength of about 380 mmu, below which the curve gradually levels out to a reflectivity of about 8% for wavelengths below about 280 mmu. This low reflectivity corresponds to rather heavy absorption of the radiation by the sheet.

In contrast to the increasing absorption of light as the wavelength is decreased from the blue and violet regions of the spectrum into the ultraviolet zone, the situation with a sheet composed of highly purified

* The groundwood used in this test and in most of the studies reported later was an eastern spruce commercial groundwood.

cellulose fibers is quite different. The spectral reflectivity of such a sheet falls off only moderately in the ultraviolet region, the ultraviolet absorption being very much smaller than that of groundwood. In fact, pure cellulose is one of the few substances having high transparency for ultraviolet radiation. Presumably the other carbohydrate components of groundwood account for only a small portion of the observed high absorption in groundwood of ultraviolet radiation and of violet and blue light. Accordingly, the yellowish color is to be ascribed to the lignin and the extractives. It is known that lignin possesses high ultraviolet absorption which varies with wavelength in a manner consistent with the observed spectral reflectivity of groundwood. This, together with evidence of a more quantitative nature to be given in later portions of this paper, indicates that lignin is mainly responsible for the characteristic groundwood color. The possible influence of the extractives should not be discounted on the basis of their low content (a few per cent), because, under certain circumstances, they may become highly colored materials. Although work on the chemical and optical properties of the extractives is in progress, it is not possible at the time of writing to estimate the importance of the part they play in the color of groundwood.

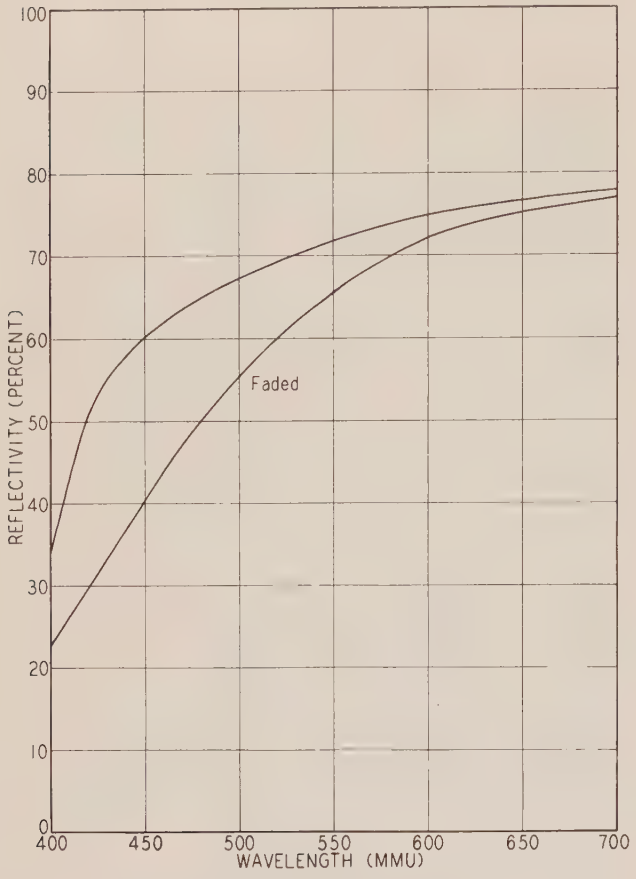

Fig. 1. Upper curve: spectral reflectivity ("color curve") of 100% groundwood before exposure to light. Lower curve: spectral reflectivity of groundwood after an integrated exposure of 73 hours of each side to the sun. The color difference corresponding to these two curves is very great

The increasing demand for white papers for color printing, and the growing use of color on newsprint intensify the importance of the problem of the color of groundwood. Another factor having a strong bearing on the problem is the increasing use of fluorescent lamps. Although such lamps are manufactured in a number of types covering a wide range of color temperature, it may be said that fluorescent lamps generally radiate light that is relatively rich in the blue portion of the spectrum. It is well known that yellows of low saturation (i.e., weak yellows) appear stronger under light of this sort than under the illumination of incandescent lamps. A yellowish paper viewed in incandescent light might pass as a reasonably good "near-white;" the same paper under a fluorescent lamp will probably appear to be objectionably yellow. It is also of interest to note that fluorescent lamps radiate near-ultraviolet light, and that such light will promote "fading" of groundwood.

THE "FADING" OF GROUNDWOOD BY LIGHT

The so-called "fading" of groundwood under the action of light is actually a deepening of the yellow color (increase in saturation or purity of color) and a darkening of the color. Fading is associated with decrements in brightness and luminous reflectance. Color curves for a groundwood paper before and after 73 hours of exposure of each side to sunlight are reproduced in Fig. 1. Inasmuch as a noticeable difference in color corresponds roughly to a change in reflectivity of 1% at wavelengths in the vicinity of 450 mmu, it is evident that the color change associated with the two curves of Fig. 1 was very profound. Actually, it is not necessary to expose groundwood to sunlight for long periods of time to obtain rather large color changes, because the modification of light absorption in groundwood paper is not directly proportional to the time; it is more nearly proportional to the square root of the exposure time—e.g., an exposure of 4 hours produces only about twice the effect of a 1-hour exposure.

It will be noticed that the greatest difference between the curves of Fig. 1 exists in the blue region of the spectrum (between 420 and 480 mmu). Since brightness (papermakers') is determined with blue light, this quantity has been widely and effectively used in technical studies of the changes in color of groundwood. Good correlation is usually to be expected in the comparison of changes in brightness with the corresponding changes in such important colorimetric quantities as purity and luminous reflectance; accordingly, where technical considerations permit, the measurement of brightness results in the acceleration of investigational work in this field. Relatively short exposure times may be employed and, of course, the determination of brightness requires very much less time than does colorimetric evaluation, even when the latter is performed with a three-filter photoelectric colorimeter.

Reference has already been made to the studies of Lewis, *et al.*, (*1–5*) on the fading of groundwood by light; it is suggested that the technical reader interested in details should consult those and other original contributions covered by the literature survey. Perhaps the present purposes may be best served by reviewing some of the more important findings of the

studies conducted at The Institute of Paper Chemistry, and by introducing, where it may appear to be helpful to do so, new considerations based on the published data.

The time of exposure of groundwood to the light from a Fade-Ometer arc or other source of ultraviolet light is related to the changes produced in the sheet in a strongly nonlinear manner. For example, the drop in brightness of a 100% groundwood sheet during the first hour of exposure to a Fade-Ometer was 5 points (61.7 to 56.7%), whereas the further drop occurring during the second hour was 2 points. Another way of expressing this result is found in the qualitative application of the Kubelka-Munk theory of the absorption and scattering of light. Strictly speaking, this theory is not applicable to a groundwood sheet *after* fading, because such a sheet is not optically homogeneous. However, only a qualitative measure of the way in which the Kubelka-Munk number, K/S, varies with the time of exposure is desired. Changes in this number are, under ideal conditions, proportional to the changes in the weights of the colored bodies present in the paper. It is found that the change in K/S varies somewhat faster than the square root of the exposure time. This relationship is to be regarded as purely empirical; it does indicate quite definitely, however, that the photochemical, or photochemically induced, reactions occurring in the sheet are extraordinarily fast at the onset of exposure, and decrease in rate with increasing exposure time. A theoretical analysis of the problem would be enormously complicated and would require much more chemical and physical data than are currently available.

The influence of groundwood content on the color and the instability of color of bleached sulphite-groundwood furnishes is disproportionate with the color changes. For example, the first increment of 20% of groundwood in the furnish produces a much larger decrement in brightness in both the unfaded and faded sheets than the last increment (from 80 to 100% groundwood). This is an important effect in practice, and is understood in the light of the Kubelka-Munk theory.

The pH of groundwood strongly influences the brightness of both the unfaded and faded groundwood paper. A study of a series of test sheets in which the pH (water extract) was varied from 2.10 to 9.88 through controlled additions of H_2SO_4 and NaOH revealed that the optimum pH with regard to maximum brightness of the unfaded and faded paper was in the vicinity of 4.0.

Several photochemical observations were made with a Hanovia Type BU mercury arc. Where it was desired to study the influences of gases, temperature, and humidity, the specimens of groundwood sheets were placed in a fused silica flask. The intensity of the mercury arc was controlled by means of a combination of fluorescent screen, photocell, and galvanometer.

The influence of oxygen on the rate of fading was not large. Two-hour exposures were made with specimens exposed to air (flask open to room), oxygen, nitrogen, vacuum for 16 hours, and vacuum for 50 hours. The data may be summarized as follows:

Atmosphere	*Points Drop*
Air	10.1
Oxygen	9.0
Nitrogen	7.0
Vacuum (16 hr.)	6.8
Vacuum (50 hr.)	7.6

The higher result obtained with air (as compared with oxygen) is probably attributable to a small humidity effect (see below). It is concluded that the role played by oxygen in primary reactions is slight, unless the small amount of oxygen sorbed by the fibers and other components of the groundwood under vacuum conditions is sufficient for any direct or catalytic effect the oxygen may have.

The effect of relative humidity is small, but definite. Two-hour exposures of specimens exposed to air of very high relative humidity (however, safely below the condensation point) and air desiccated for 22 hours with phosphorus pentoxide resulted in brightness drops of, respectively, 10.9 and 8.0 points. Pure water (like pure cellulose) has high transparency for ultraviolet radiation and, hence, any real effect of moisture content is small, although definite.

Temperature, per se, has very little effect on the color of groundwood, but the temperature coefficient of the photochemical effects is quite large. Specimens exposed to air at 100°C. for varying periods of time in the darkness exhibited an average drop in brightness of 0.5 point after 2 hours of aging, and only 1.2 points after 8 hours. However, 2-hour exposures to ultraviolet radiation at room temperature and at 100°C. resulted in brightness drops of, respectively, 10.1 and 14.0 points. At this lowered level of brightness, the influence of temperature alone would be substantially less than 0.5 point, so that the 40% increase in the brightness drop caused by the simultaneous exposure of groundwood to elevated temperature and ultraviolet radiation is to be interpreted as meaning that the photochemical effect has a substantial temperature coefficient.

The spectral sensitivity of groundwood (the dependence of fading on the wavelength of radiation) is of particular interest. This was determined by means of a monochromatic illuminator and a vacuum thermojunction for the measurement of radiation intensity. The energy of the radiation at any given wavelength was obtained by multiplying the intensity by the exposure time; the sensitivity of the groundwood at that wavelength was taken as proportional to the reciprocal of the radiant energy required to produce a given drop in brightness. The relative spectral sensitivity curve, determined in this manner, is given in Fig. 2. This figure also presents the spectral absorption coefficients of native lignin and lignin derivatives. The similarity in shapes of the spectral sensitivity curve for groundwood and the ultraviolet absorption curves for lignin is striking, and is believed to be significant of the part played by lignin in the instability of color of groundwood. It is known that, in general, the photochemical behavior of a substance is related to the spectral absorption of the substance. It has been concluded (*2*) that, *"This agreement between the shapes of the curves indicates quite definitely that the absorption of light by lignin in groundwood is responsible for initiating at least a portion of the reactions that give rise to the charac-*

teristic yellowing of the color of exposed groundwood. This agreement in shape of the two types of curves is not sufficient in itself to indicate that the lignin *per se* is suffering a permanent change in chemical composition produced by the action of light, because it does not rule out the possibility that the lignin is acting as a catalyst for the photochemical reaction; however, both the increase in alkali solubility of the faded sheet and the temperature variation of the rate of reaction indicate that the lignin in itself must be modified in some manner by the action of light, and associated with this modification is the increase of the absorption coefficient in the visible spectrum and the consequent yellowing of the sheet."

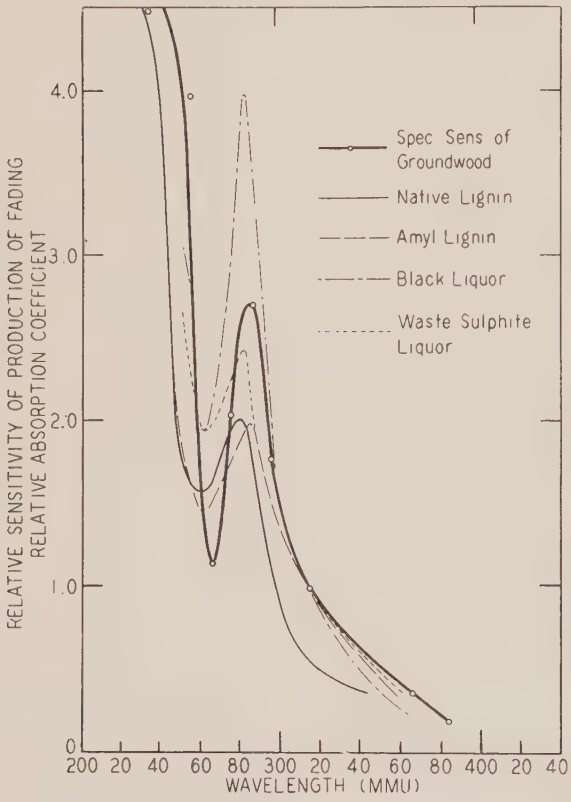

Fig. 2. The heavy curve gives the relative spectral sensitivity of production of fading, or the relative effectiveness of different wavelengths in the ultraviolet region in producing lowered brightness. The lighter solid line and the remaining curves give the relative spectral absorption coefficients of native lignin, amyl lignin, and of lignin derivatives dissolved in black liquor and waste sulphite liquor

A bleaching of groundwood, amounting to about 2 points in brightness, results when a sheet is exposed to intense radiation (incandescent source) from which light of wavelength shorter than about 480 mmu has been filtered out. However, when the radiation contains light of wavelengths down to about 385 mmu, a brightening of the groundwood is observed only during the first portion of the exposure period and, subsequently, the brightness falls off with increasing exposure. Associated with these phenomena are different types of modification of the color curves of the groundwood. In contrast with the ordinary effect of short-wavelength radiation (see, e.g., Fig. 1), radiation of wavelength longer than about 350 mmu produces very little drop in reflectivity at 400 mmu, but lowers the color curve for wavelengths above 450 mmu. The brightening effect of light of wavelength longer than 480 mmu applies to the whole color curve, from 400 to 700 mmu. These observations lead to the conclusion that there are at least two photochemical effects that occur during the normal fading of groundwood. (It is perhaps of interest, in passing, to note that most window glasses will transmit light of wavelength down to about 350 mmu.)

The effect of ozone on groundwood color is that of bleaching. It was, therefore, of considerable interest to find that the drop in brightness caused by exposure to the radiation from the mercury arc was doubled when ozone was added to the air streaming around the test specimens (8 micrograms of ozone per milliliter of air). It seems possible that the bleaching action of ozone (absence of ultraviolet light) is similar to that of long-wavelength light and that ozone, a powerful oxidizing agent, can participate in the fading reactions only in the presence of ultraviolet radiation. As is well known, the quantum energy of ultraviolet radiation is sufficiently high (e.g., 4.1 electron-volts or 95 kg.-cal. per mole at 300 mmu) to disrupt a number of the linkages in organic substances, and it seems probable that the oxidizing action of ozone in the fading reactions can occur only after certain linkages are broken by the radiation.

Studies of the chemical changes produced by ultraviolet radiation in groundwood were made with (a) groundwood sheets exposed to the Fade-Ometer for 10 hours on each side (brightness drop, 21 points) and with (b) a commercial groundwood book paper containing 45% groundwood, 55% bleached sulphite (ash-free basis), and 15% clay, exposed for integrated periods of 73 hours on each side to August sunlight (brightness drop, 11.3 points). The results will be summarized here for the convenience of the reader not interested in the detailed data.

The prolonged exposures decreased the apparent lignin content and the methoxyl content; these decrements were substantially larger in the case of the paper exposed to sunlight. The corresponding reactions, involving a loss of methoxyl groups, may be followed by chemical modification to a colored substance. A study by Forman (7) of the action of ultraviolet light on lignin is of considerable interest in this connection. A portion of his summary of observations and conclusions is quoted in the following: "Alcohol extraction of irradiated wood meal or lignin yields colored solutions of reaction products made alcohol soluble by the action of the light. Evidence is presented which indicates that these alcohol solutions contain a mixture of lignin degradation products, some of which are obviously products of oxidation reactions. One such fragment was vanillin. Another, having a methoxyl content of 10.6%, showed some physical resemblance to native lignin. The presence of vanillin in a sheet causes rapid fading of the sheet on irradiation. (This observation was made with a sheet of filter paper impregnated with vanillin.)

"The action of ultraviolet light on lignin is very complex. The primary reaction probably involves the rupture of linkages and rearrangements of structure which make available new points of attack for

such reactions as photochemical oxidation. The secondary reactions probably include the formation of a series of oxidation products which in turn may form colored compounds by polymerization."

Cross and Bevan cellulose was appreciably reduced in the groundwood exposed for 10 hours per side to the Fade-Ometer but was not changed in the groundwood paper exposed to sunlight for an integrated time of 73 hours per side; pentosan contents were reduced in both papers. It should be noted that sunlight and the light from a Fade-Ometer arc do not have the same relative spectral energy distribution in the ultraviolet region. Presumably the ultraviolet radiation from the Fade-Ometer arc shortened the carbohydrate chain molecules through attack of the glycosidic linkages, and caused an increase in the copper number and alkali solubility (both of which were observed to increase). Heuser (*8*) presents a thorough discussion of the action of ultraviolet light on cellulose, and recent work of interest on this subject has been done by him and his co-workers, Stillings and Van Nostrand (*9*) and Chamberlin (*10*).

The alkali solubility (1% NaOH) and *copper number* of the papers exposed to both the Fade-Ometer and sunlight increased several fold. It was possible to show that all but a few per cent of the original lignin was rendered soluble by the irradiation. The *ethanol-benzene solubility,* although small, was increased severalfold.

The state of chemical knowledge of lignin, of the degradation products of lignin, and of the other components of groundwood is not sufficiently far advanced to permit one to draw definite conclusions concerning the relationship between the color and chemical changes produced in groundwood by irradiation with ultraviolet light. However, in agreement with Hirschkind (*11*), Bakker (*12*), and others, it appears certain that the yellowing and darkening of the color of groundwood is to be ascribed either to a modification of the lignin or to products resulting from such modification, or to both.

NATURE OF THE CHANGE IN COLOR OF GROUNDWOOD CAUSED BY SODIUM PEROXIDE BLEACHING

The pioneering work of Reichert and his co-workers (*13–16*) has resulted in a commercial process for bleaching groundwood with sodium peroxide that is remarkable from several points of view. They, and more recently Stobo and Russell (*17*), have shown that, working with groundwood pulps prepared from woods that are amenable to bleaching by this process, brightness increments of the order of 10 points can be achieved in an operation in which the weight of sodium peroxide is only 2% of the oven-dry weight of the pulp. It is unnecessary to point out that a bleached groundwood having a brightness in the range 70 to 75% may be used in the production of paper having a good degree of whiteness.

During a recent thesis study conducted by one of the authors (G. W. J.) (*18*) on the effect of sodium peroxide bleaching on groundwood, the part played by lignin was investigated chemically and colorimetrically. Of particular interest in the present discussion is the demonstration, through optical theory and measurement, of the relationship between the color of bleached groundwood and the colorimetric properties of lignin extracted from unbleached groundwood and of lignin extracted from bleached groundwood.

This work involved the color of lignin solutions, which brought Beer's Law (shown to hold for such solutions) into play, and the optical work relating to the color of groundwood test sheets was that based on the well-known Kubelka-Munk theory of absorption and scattering of light in light-scattering media. A very interesting aspect of the investigation is the assumption that the extinction coefficient for a material in solution is the same as the specific absorption coefficient of that material when present in a sheet of paper. Mathematically, these coefficients should be identical *if there is no optical solvent effect on the material.* This is the last of four basic assumptions made below.

The basic assumptions required for the analysis (to be shown subsequently to be valid or false by the experimental data) are:

(a) Isolated native lignin and the total lignin in spruce groundwood are of the same intrinsic color—that is, their specific absorption coefficients are essentially identical.

(b) Sodium peroxide bleaching alters the color of the extractable native lignin and of the total lignin in groundwood in essentially the same manner.

(c) The major bleaching exerted by sodium peroxide upon the pulp is the result of its reaction with the total lignin component. Consequently, the color of the nonlignin portion of the groundwood is assumed to be essentially unaltered by the action of sodium peroxide.

(d) Anhydrous dioxane exerts no appreciable solvent effect (with regard to the absorption of light) upon isolated native lignin.

The analysis involved the setting up of equations for the specific absorption coefficients of the unbleached and bleached groundwood sheets in terms of the specific absorption coefficients of the lignin and nonlignin components. The coefficients for the sheets were determined from reflectance data obtained with the General Electric recording spectrophotometer, using well-established procedures based on the Kubelka-Munk theory. The extinction coefficients of the extracted lignin from the unbleached and bleached sheets were determined through spectral transmittance determinations (made with the G. E. recording spectrophotometer), and with the help of Beer's Law. These extinction coefficients were then used as specific absorption coefficients in the equations for the paper sheets. Finally, the reflectivity of the bleached groundwood was calculated and compared with the directly observed reflectivity of the groundwood. It should be emphasized that the calculated reflectivity depends upon the numerical values of the extinction coefficients of the unbleached and bleached lignin isolated from the unbleached and bleached groundwood. The calculated and observed reflectivities of the bleached groundwood are compared in Fig. 3. When one considers the technical details of what has been done, it is realized that the agreement between the two curves

is remarkable. The small spread between the curves for wavelengths below 500 mmu may, or may not, be real. The opacity of the test sheets was (as might be expected) quite high for the short wavelengths and, accordingly, the experimental uncertainty increased as the wavelength approached the violet end of the spectrum.

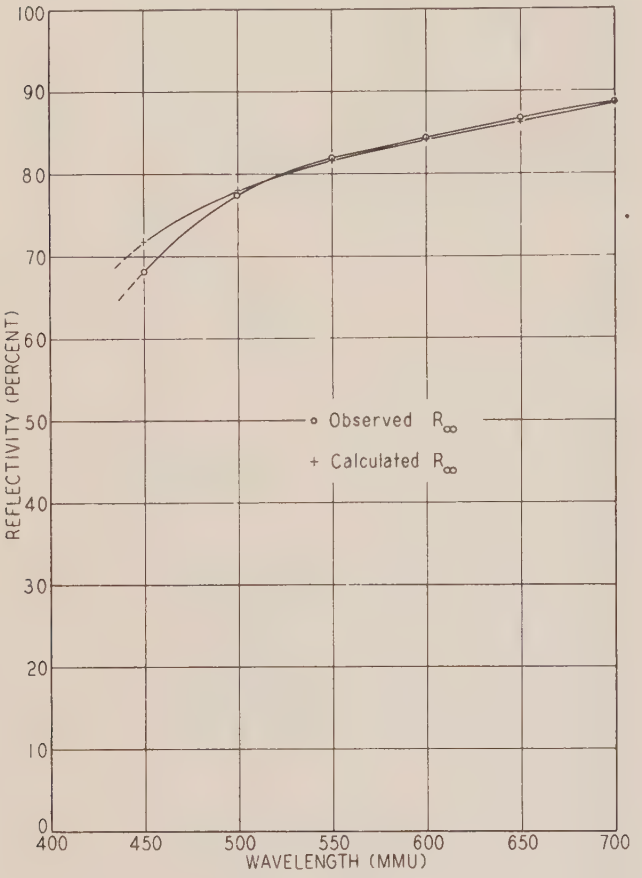

Fig. 3. Observed and calculated spectral reflectivity ("color curve") of bleacher groundwood. The calculated spectral reflectivity is based on spectral absorption measurements of isolated lignin from unbleached and bleached groundwood, existing in dissolved form in dioxane solutions

It is concluded that sodium peroxide bleaches groundwood almost wholly through its action on the total lignin in the pulp. A subsidiary conclusion of technical interest is that the bleaching action on that portion of the lignin which is extractable (native lignin) is the same as that on the total lignin. Another conclusion of importance is that, in spite of the fact that the nonlignin components consume a substantial amount of the sodium peroxide, the nonlignin components are not bleached. Since pure carbohydrates are white, the interest in this conclusion attaches to the action of the sodium peroxide bleaching process on the extractives.

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Received Nov. 12, 1948. Presented at the Mechanical Pulping Conference, sponsored by the Technical Association of the Pulp and Paper Industry and Technical Section, Canadian Pulp and Paper Association, Poland Spring, Me., Sept. 27–29, 1948.

Note added in proof. In the third paragraph of the section entitled "Nature of the change in color of groundwood caused by sodium peroxide bleaching," it is stated that "the extinction coefficient for a material in solution is the same as the specific absorption coefficient of that material when present in a sheet of paper." Recently, one of the authors* has examined the theoretical connection between the absorption coefficients of a material in solution and in a light-scattering medium, and has shown that, whereas the defining differential equations for light *absorption* are the same for solution and light-scattering medium, the coefficients should not be numerically equal. When allowance is made for the fact that parallel rays normal to the absorption cell are employed in measuring a (the absorption coefficient of a material in a nonturbid solution), whereas the light in a diffusing medium such as paper is nearly the same in all directions (for which geometry the specific absorption coefficient k is appropriate), it is found that $k = 2a$. Thus, in the ideal case, the two coefficients differ by a factor of two. If an extractable (colored) material like lignin is not uniformly dispersed in the pulp or paper, its contribution to the k-value of the latter should be less than $2a$; thus, we may write $k = 2fa$, where f is a "distribution factor" having a value less than unity. In view of this correction, the agreement between the observed and calculated reflectivity curves shown in Fig. 3 may have been obtained through the happenstance that f was about 0.5. However, the approximate agreement of the curves with regard to *form*, and with regard to numerical values with a very plausible value of f, at least qualitatively supports the conclusions which had been drawn from the observations.

* J. A. Van den Akker. "A note on the coefficients of the Kubelka-Munk theory of the scattering and absorption of light in paper and other diffusing media." To be published soon.

ASSOCIATION NEWS AND EVENTS

TAPPI Coating Conference

The 1949 Coating Conference of the Technical Association of the Pulp and Paper Industry will be held at the Pantlind Hotel, Grand Rapids, Mich., on April 26–27, 1949. Room reservations should be made direct with the hotel.

The tentative program of the technical sessions is as follows:

Tuesday, April 26, at 9:00 a.m.

1. "The Mechanics of Adhesion in Mineral Coated Papers with Particular Emphasis on Testing Methods," by Glenn Davidson, Aurora, Ill.
2. Panel Discussion of Mr. Davidson's paper.

Tuesday, April 26, at 2:00 p.m.

1. "Application of Styrene-Butadiene Copolymers as Adhesives in the Production of Mineral Coated Printing Papers," by E. K. Stilbert, Dow Chemical Co., Midland, Mich.
2. "The Use of Hydroxyethyl Cellulose as an Adhesive in the Production of Mineral Coated Printing Papers," by D. Robert Erickson, Consultant, Kalamazoo, Mich.

Wednesday, April 27, at 9:00 a.m.

1. "Development of Soy Protein for Paper Coating with Emphasis on Viscosity, Color, and Adhesive Strength," by A. Gotthoffer, Drackett Products Co., Cincinnati, Ohio.
2. "The Use of Titanium Pigments for Paper Coating," by William R. Willets, Titanium Pigment Co., New York, N. Y.

Wednesday, April 27, at 2:00 p.m.

1. "Development and Application of the Microjet and Syncroset Coater," by B. R. Newcomb and A. J. Gaio, John Waldron Corp., New Brunswick, N. J.
2. Panel Discussion on Paper Machine Coating and Other Coating Subjects.

There will be a dinner at 6:30 p.m. on April 26, followed by attendance at St. Cecelia Theater at a play "John Loves Mary" by the Grand Rapids Civic Players.

On Wednesday, April 27, Dwight Stocker, President of the Michigan Paper Co., Plainwell, Mich., will preside as toastmaster at the group luncheon. The principal speaker will be Benton R. Cancell, Vice-President, St. Regis Paper Co., Deferiet, N. Y.

Mill Visits: Thursday, April 28, will be devoted to visits to the paper and coating mills in the Kalamazoo area. Bus transportation will be furnished. The following mills will have open house: Allied Paper Mills, Hawthorne Paper Co., Kalamazoo Paper Co., Kalamazoo Vegetable Parchment Co., Lee Paper Co., Mac Sim Bar Paper Co., Michigan Paper Co., Rex Paper Co., Bryant Div., St. Regis Paper Co., and Sutherland Paper Co.

Ladies Program: Ladies are welcome to attend the meeting. Features of a special program that has been arranged for them will be a hat show and tea on April 26 and a conducted tour of the Furniture Mart. They will be welcome at all other scheduled events during the meeting.

Chairmen of Committees:

General Chairman—Paul W. Bartholomew, Hawthorne Paper Co., and Chairman of the Kalamazoo Valley Section.

Program Chairman—W. A. Kirkpatrick, Allied Paper Mills.

Entertainment, Transportation, and Mill Visits Committee—R. R. Buss, Hercules Powder Co.

Printing Committee—Jack Dickson, R. T. Vanderbilt Co.

This conference is a national meeting sponsored jointly by the Coating Committee of the Technical Association of the Pulp and Paper Industry, Werner Kaufmann, Kupfer Bros. Paper Co., Chicago, Ill., Chairman, and of the TAPPI Kalamazoo Valley Section.

Correction to T 230 sm-46

Kenneth E. Pinkerton of Filter Materials, Inc., Waupaca, Wis., has reported an error in TAPPI Standard T 230 sm-46 Cupriethylenediamine Disperse Viscosity of Pulp. In the second column on the back of sheet 2 the headings under "cupriethylenediamine" in the table are transposed. The fourth column should be 0.167 *M* and the fifth column should be 1.00 *M*. As the table now stands, the resulting

Annual Luncheon, Technical Association of the Pulp and Paper Industry, Commodore Hotel, New York City, February 24, 1949

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solution would be 0.6668 *M*, but (reversing the columns) 15 ml. of 0.167 *M* solution plus 10 ml. of 1.00 *M* solution would give a solution of 0.5002 *M*, which is the strength desired.

The whole question of disperse viscosity of pulp is under review by the TAPPI Chemical Methods Committee, Milton Fillius, Eastman Kodak Co., Rochester, N. Y., Chairman, and this typographical error will be corrected in the next mailing of the Standards.

Report of Executive Committee

The following is a report of the Executive Committee Meeting held in New York City on Feb. 20, 1949; convening at 10:00 a.m.

Rountine Control Methods

The Secretary reported that the methods which were edited by Roger C. Griffin, Chairman of the Standards Committee, have been received by the Association office. These will be typed, edited further, and prepared for publication in loose-leaf form. They will be distributed to members during the current year.

Monographs

Werner Kaufmann, Chairman of the Coating Committee, reported that two monographs will be ready for publication this year. These are to be entitled "Adhesives for Paper Coatings," and "Paper Coating Machinery."

Ward D. Harrison, Chairman of the Pulp Purification Committee, reported that good progress is being experienced in the preparation of a book on Bleaching. It is likely that it will be ready for publication in 1949.

Local Sections

Present at this meeting were the chairmen of most of the local sections of the Association. Brief reports were given. More complete reports will be published throughout the year in the Local Sections Activities section of *Tappi*.

The Secretary requested that meetings and other activities of the sections be reported in the form of News-Letters.

Coating Conference

Paul Bartholomew, Chairman of the Kalamazoo Valley Section, reported that plans were nearly complete for the TAPPI Coating Conference to be held at the Pantlind Hotel, Grand Rapids, Mich., on April 26–27, 1949. (A complete program of this meeting is published in this issue of *Tappi*.)

Fall Meeting on Pacific Coast

H. W. Bialkowsky outlined the present plans for the fall meeting program of the Association. This meeting will be held at the Multnomah Hotel, Portland, Ore., on September 11–15.

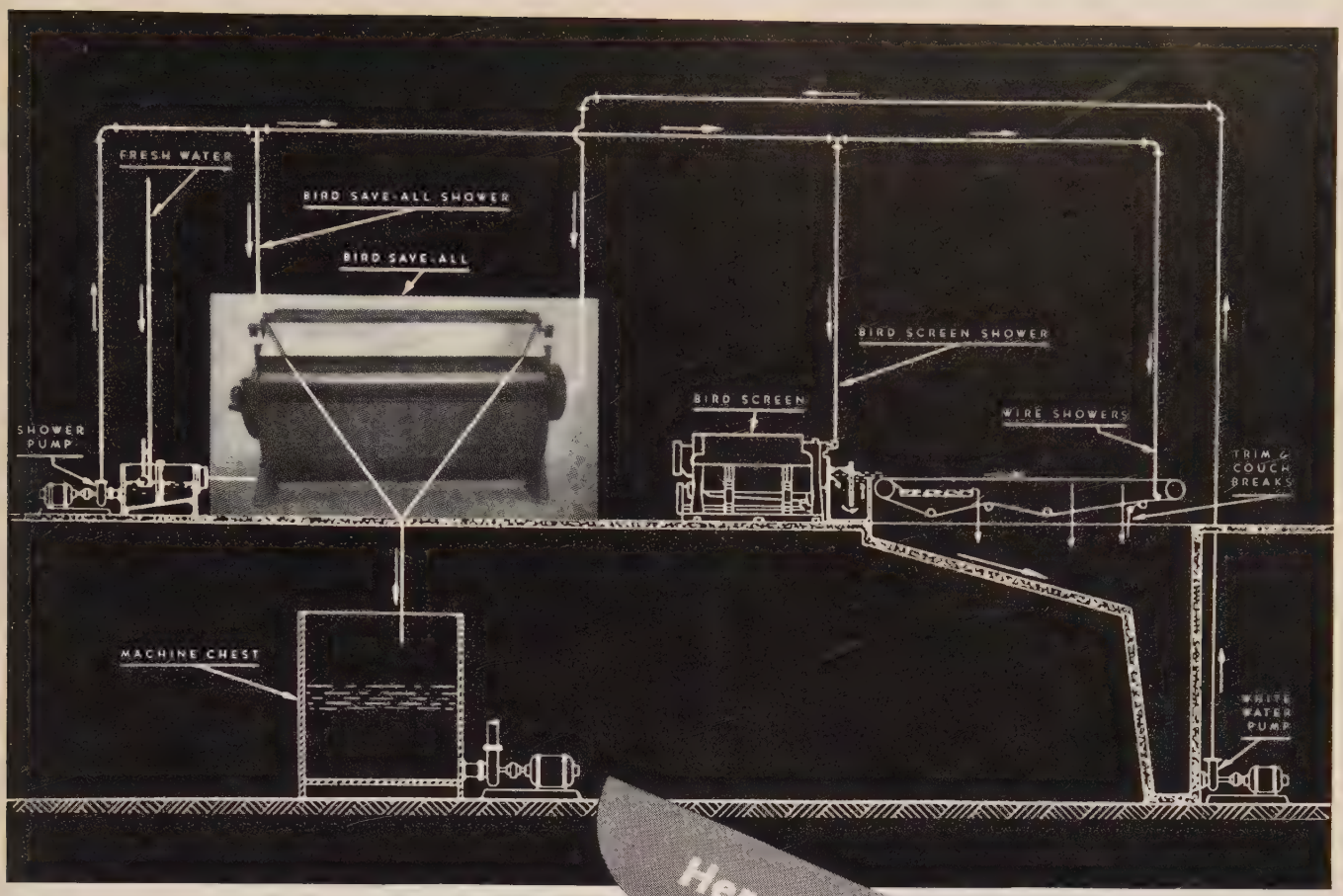
(Most of the individuals who attended the annual meeting in New York obtained an envelope containing complete details regarding the train schedules, etc. This material will be mailed to all members soon and each issue of *Tappi* will contain publicity displays regarding the meeting plans.)

Fourth Engineering Conference

J. W. Hemphill, General Chairman of the Engineering Division, reported that good progress is being made in preparing a program for the Fourth Engineering Conference of the Pulp and Paper Industry which will be held at the Statler Hotel, Boston, Mass., on October 31, Nov. 1–3, 1949.

Mr. Hemphill also reported that he had received an invitation from the Ohio Section inviting the Association to hold the Fifth Engineering Conference at Cincinnati, Ohio. Final decision regarding this will be made at the Boston Conference.

(*continued on page 40 A*)



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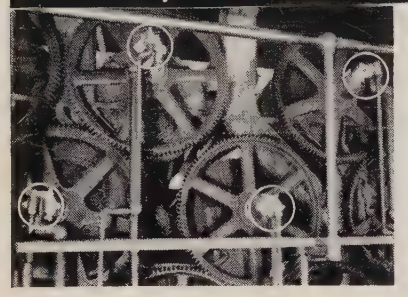

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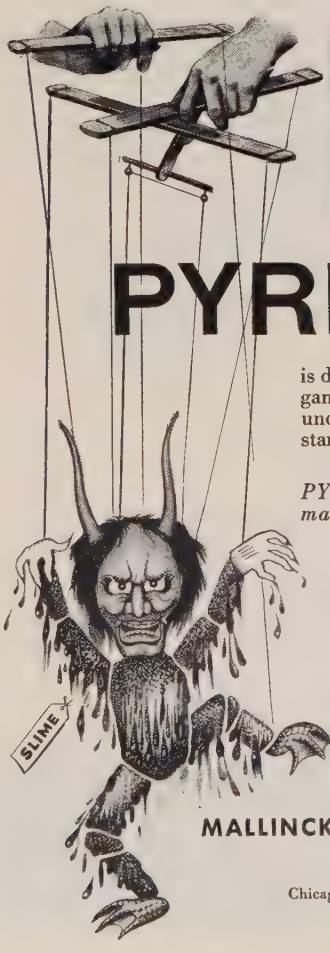

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(*continued from page 38 A*)

Appointment of Nominating Committee

With the approval of the Executive Committee, President Gillespie appointed the following to serve as members of the 1950 Nominating Committee to prepare a slate of candidates to be voted on by mail ballot prior to the 1950 annual meeting:

Principals:
Henry Perry, Consulting Engineer, New York, N. Y.
H. H. Hanson, W. C. Hamilton & Sons, Miquon, Pa.
H. E. Karberg, Alliance Paper Mills, Merritton, Ont.
C. H. Child, Merrimac Paper Co., Lawrence, Mass.
H. Y. Charbonnier, Union Bag & Paper Corp., Savannah, Ga.

Alternates:
O. P. Geoppinger, Marcal Paper Co., E. Paterson, N. J.
J. R. Dufford, Paterson Parchment Co., Bristol, Pa.
J. B. Beck, E. B. Eddy Co., Hull, P. Q.
G. D. Bearce, St. Regis Paper Co., Bucksport, Me.
A. D. Levert, Gaylord Container Corp., Bogalusa, La.

The terms of the following Officers and Executive Committeemen expire in February, 1950:

President—A. E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt.
Vice-President—K. P. Geohegan, Aetna Paper Div., Dayton, Ohio
Executive Committeemen:
J. D. Davis, Dill & Collins Div., Philadelphia, Pa.
K. O. Elderkin, Crossett Paper Mills, Crossett, Ark.
A. C. Hill, Montmorency Paper Co., New York, N. Y.
R. A. Wilkins, Bird & Son, Inc., E. Walpole, Mass.

Student Membership

It was voted to approve an amendment to the Association Constitution (Art. III, Sec. 4) to read:

"A student member shall be a bona fide matriculated full-time student and candidate for a degree at a recognized school or shall be an individual under twenty-four years of age who may hold a subordinate position of a technical nature in the pulp and paper industry."

The annual dues of a student member was established at $7.50.

Note: This amendment will terminate the existence of the present junior grade of membership. It will be necessary for members to vote on this amendment by mail ballot later in the year.

Research Grants

John L. Parsons, Chairman of the Research Appropriation Committee, requested that the Executive Committee clarify its policy with regard to approving grants.

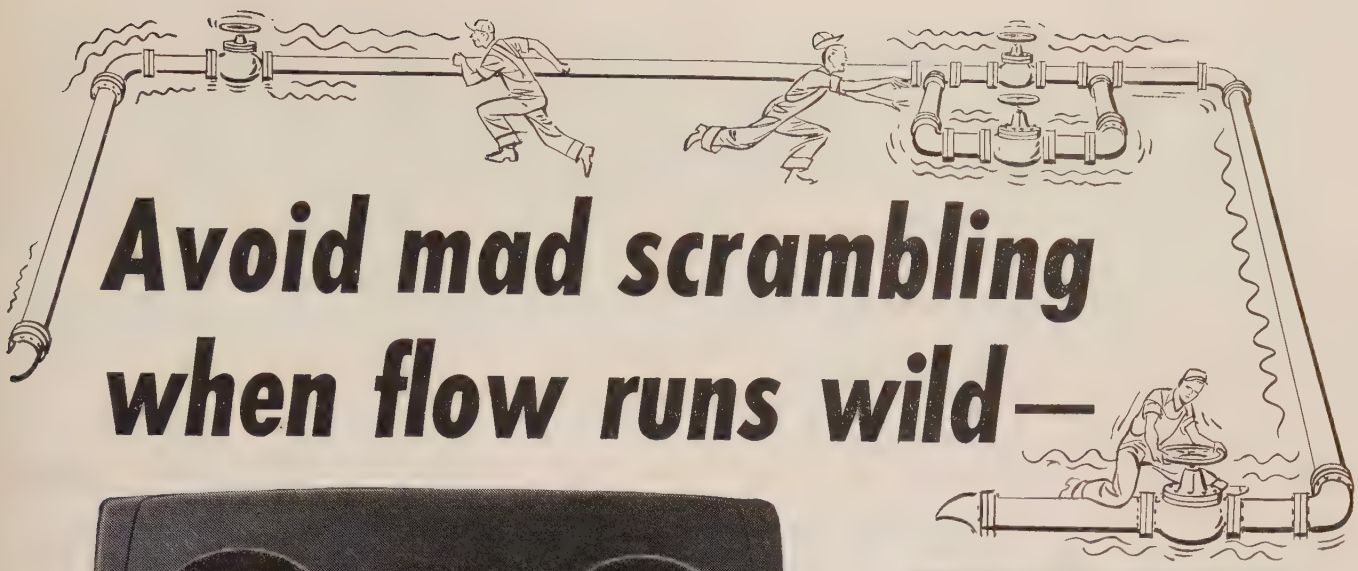
The members of the Executive Committee agreed that the Research Appropriation Committee should not be required to pass on the merits of a project offered to it through authorized channels. It was felt that the initiating committee should assume this responsibility.

In general, it was the opinion of the Committee that requests for research grants should be initiated by a regular Association committee in connection with the completion of one of its bona fide projects. It was felt that a project could be recognized as bona fide provided that the initiating committee maintained continuous supervision over the establishment and execution of the project. A report of the results of the research work must be published in *Tappi* under the sponsorship of the Research Appropriations Committee and the initiating committee.

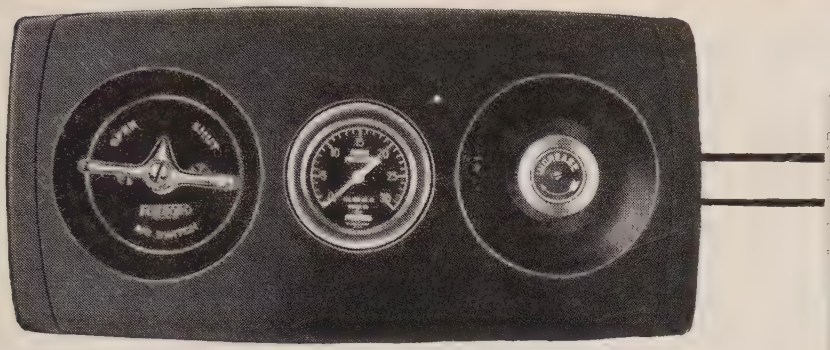
Publication Management Committee

The following were appointed to serve as members of the Publication Management Committee until February, 1950: K. P. Geohegan, Aetna Paper Div., Chairman, H. W. Bialkowsky, Weyerhaeuser Timber Co., G. J. Brabender, Marathon Corp., J. W. Hemphill, Johns-Manville Corp., and Werner Kaufmann, Kupfer Bros. Paper Co.

(*continued on page 42 A*)



Avoid mad scrambling when flow runs wild—



. . . with this New Remote Valve Control System

Now — those big, inaccessible valves throughout your plant can all be remotely controlled from a central panel. No more rushing around to adjust them by hand . . . now it's simple, fast, far more accurate and efficient. And the operation can be made automatic, if you wish, with the use of Foxboro Model 40 Controllers.

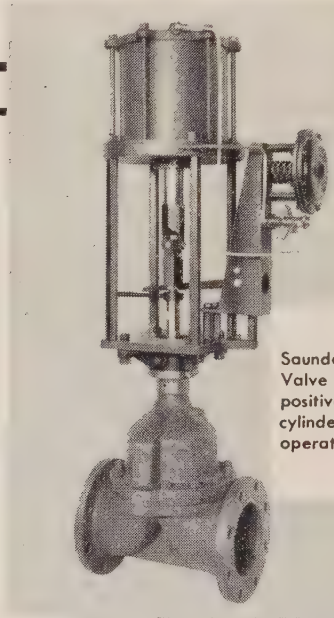
The system for manual operation consists of a valve of your choice, equipped with the new Foxboro *pneumatic* or *hydraulic* positive-positioning cylinder type operator, plus the standard Foxboro Remote Control Panel pictured above. Note the switch for fast open-shut operation, the gauge which shows valve opening, and the control knob for the precise adjustment of this valve opening.

A VALVE FOR ANY FLUID-FLOW

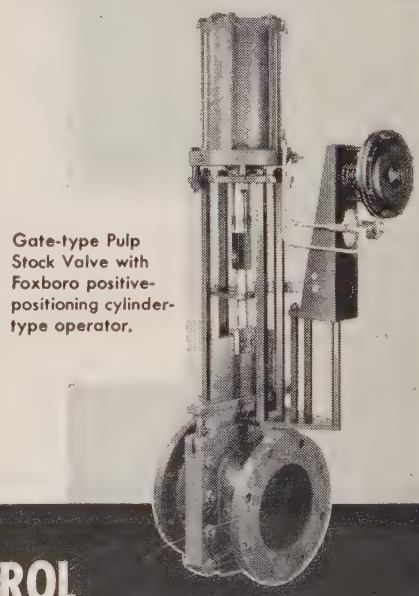
Typical of the valves supplied by Foxboro for this service is the Saunders Patent Valve shown at top — recommended for corrosive fluids or those containing fibrous or mineral solids in suspension.

The gate-type pulp stock valve shown at the bottom is used for service involving temperatures and line sizes beyond the practical limits of other valve types.

Here's a new system that simplifies valve operation . . . centralizes it . . . and eliminates a lot of confusion at the same time. Write for complete details. **The Foxboro Company, 78 Neponset Ave., Foxboro, Mass., U. S. A.**



Saunders Patent Valve with Foxboro positive-positioning cylinder-type operator.



Gate-type Pulp Stock Valve with Foxboro positive-positioning cylinder-type operator.

FOXBORO REG. U. S. PAT. OFF. **FLOW CONTROL**

(*continued from page 40 A*)

Following the annual meeting in 1950 the President shall appoint members of the Executive Committee to serve as personnel of the Committee, the Vice-President of the Association to preside as chairman.

The advertising contracts for *Tappi* were reviewed. The Committee expressed its appreciation of the unusually fine vote of confidence indicated in the large number of companies that have agreed to use advertising space in *Tappi* during 1949.

Editorial Board

C. J. West, Chairman of the Editorial Board, was present and outlined the procedure for considering manuscripts for publication. A number of the manuscripts offered were rejected for publication on the basis of either being incomplete, having been published in some form before, being an inadequate review, belonging in another type of magazine or trade journal, or being of a distinctly advertising nature.

Dr. West reported that consideration is being given to the great breadth of interest of Association members and their need for information of a practical as well as a technical nature. It was felt that such literature can be supplied without decreasing the high standards relative to the quality of the presentation.

It was agreed that papers prepared by nonmembers of the Association would be acceptable for publication; papers presented at meetings of other associations could be considered; and that nonmembers of the Editorial Board could be invited to review papers that are offered.

Dr. West indicated that the Association policy of requiring that test results be expressed in the terms used in the TAPPI Standards should be enforced by the Editor, rather than the Editorial Board.

To provide a means of rotating service on the Editorial Board it was agreed that each member serve on a term basis so that one third of the Board be retired as members each year, although such members would be eligible for reappointment for a three-year term. On an alphabetical basis the order of term occupancy will be as follows: To retire in February, 1950—Messrs. West, Aronovsky, Campbell, Clark, Cowan, Griffin, Harrison, and Heuser; in 1951—Messrs. Holzer, Jahn, Lewis, Malcolmson, Mark, Miller, and Montgomery; in 1952—Messrs. Moon, Parsons, Perry, Sherwood, Sutermeister, Tomlinson, and Wehmhoff.

To conform to the Post Office requirements the following resolution was passed and was further read and approved at the first general session held during the annual meeting:

"Be it resolved that the Association establish a monthly technical magazine, to be designated by the title Tappi."

"Be is further resolved that a copy of Tappi *be sent regularly to each member of the Technical Association of the Pulp and Paper Industry in consideration of the payment of $7.50 per annum, said amount to be included in the annual membership dues of each member."*

The meeting adjourned at 6:00 p.m.

R. G. Macdonald, *Secretary*

1948 TAPPI Standards Mailing

The Association recently issued the following new and revised Standards to its members:

(1)	E 602	s-48	Specification for Chemical Composition of Process Water for Manufacture of Groundwood Papers
(1)	T 634	m-47	Melting Point of Petrolatum
(2)	T 479	sm-48	Smoothness of Printing Paper
(3)	T 470	m-47	Edge Tearing Resistance of Paper (Finch Method)
(3)	T 471	m-47	Testing Analytical Filter Papers
(4)	T 15	m-48	Ash in Wood
(4)	T 217	m-48	Brightness of Pulp
(4)	T 218	m-48	Forming Handsheets for Optical Tests of Pulp
(4)	T 219	m-48	Bleach Requirement of Pulp
(4)	T 223	m-48	Pentosans in Pulp
(4)	T 452	m-48	Brightness of Paper
(4)	T 453	m-48	Heat Test for Relative Stability of Paper
(4)	T 458	m-48	Surface Wettability of Paper (Angle of Contact Method)
(4)	T 461	m-48	Flammability of Treated Paper and Paperboard
(4)	T 467	m-48	Paraffin Wax Absorbitiveness of Paper
(4)	T 629	m-48	Analysis of Sulphite Waste Liquor
(4)	T 630	m-48	Melting Point of Paraffin Wax
(5)	E 600	s-48	Specifications for Chemical Composition of Process Water for fine Paper Manufacture
(5)	T 429	m-48	Alpha-, Beta-, and Gamma-Cellulose in Paper
(5)	T 446	m-48	Moldability (Crease Retention) of Wrapping Paper
(5)	T 459	m-48	Wax Test for Surface Strength of Paper
(5)	T 472	m-48	Compression Resistance of Paperboard (Ring Crush Test)
(5)	T 625	m-48	Analysis of Sulphite Black Liquor
(6)	T 475	m-47	Bleeding Resistance of Asphalted Paper at Elevated Temperature

(1) New Tentative Standards. (2) New Suggested Method. (3) Suggested Methods to Tentative. (4) Tentative to Official. (5) Corrected Standard. (6) Revised Standard.

1948 TAPPI Data Sheet Mailing

The following supplementary Data Sheets were recently mailed to all members:

20B	Nomograph for Williams Freeness
67	Fuel Oil Calorific Values (Corrected)
113A	Viscosity of Cellulose
120G	Circumferential Speed of Grinder Pulpstones
120H	Grinder Pocket Unit Pressure
127B	Humidity and Temperature (Corrected)
130A	Humidity over Glycerine Solutions
136–8	American Paper Color Manufacturers (Corrected)
142	Physical Constants of Pigment-Water Suspensions (Corrected)
146	Fuel and Soda Value of Tall Oil Skimmings
147	Brightness of Mixed Pulp Furnishes
148A-E	Solubility of Sulphur Dioxide
149	Nomogram of Clark Softness (T 451 m)
150	Pulpwood Losses
151A	Fuel Cost Comparison
151B	Fuel Value of Wood

EMPLOYMENT SERVICE

In accordance with the Association's long established practice of doing as much as possible to aid members seeking employment or other personal assistance the following notices are published. Responses should be addressed to the Technical Association of the Pulp and Paper Industry, 122 E. 42nd Street, New York 17, N. Y. Be sure to indicate Code Number in replies.

Positions Wanted

E1-49. Pulp and paper mill engineer. Translations prepared to and from German, French, and Russian.

E2-49. Plant engineer, 29, married, Penn. State grad. Recently chief engineer of large converter. Experience in large pulp and paper company, maintenance, construction, processes, cost control. Interested in position leading to management.

E3-49. Chemist-executive, 39, married, Ph.D., 14 years' diversified experience in developing products for paper, plastics, textiles. Desires administrative position in research and development.

E4-49. Chemist, 35, married. Experienced in application of resins, waxes, development of adhesives and binders.

E5-49. Chemist, Ph.D. Chicago U., 52, married. Experienced in research and development in waste wood utilization.

(*continued on page 44 A*)

SULPHUR

*Interesting Facts Concerning This Basic Raw Material from the Gulf Coast Region

*MAN MADE MOUNTAINS

Sulphur from the field collecting stations is delivered to the vats through insulated pipe lines which discharge directly on the vats. The sulphur is pumped at such a rate that the height of the vat is increased only a few inches per day, the slight vertical rise being the result of a large horizontal area which provides maximum cooling surface and ample tonnage capacity. As the sulphur solidifies it gradually builds up into a great block or vat of solid sulphur, which may be as large as 1200 feet long, 50 feet high, and 200 feet wide, and containing as much as half a million tons of sulphur.

The discharge lines are placed so that the liquid sulphur is spread in an even layer over the entire surface of the vat and is permitted to solidify uniformly. If the liquid sulphur is introduced too rapidly or is not properly distributed, pockets of liquid sulphur will be covered by a crust and remain in the solid sulphur. The low heat-conductivity of sulphur might keep such pockets liquid for a year or more.

Loading operations at one of the huge vats of Sulphur at our Newgulf, Texas mine. Such mountains of Sulphur are constantly being built at our mines, from which shipments are continually made.

TEXAS GULF SULPHUR CO. INC.

75 East 45th St. New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas

(*continued from page 42 A*)

E6-49. Chemical Engineer, 39. Fifteen years' experience in pulp and paper in U.S.A. and Canada, in newsprint, kraft pulping, paperboard, stock preparation, bleaching.

E7-49. Chemical engineer, 26, B.S. 1944 Worcester Poly. Inst., married. Now employed. Desires responsible position in production or technical work with progressive company. Experienced in pulp and paper mill research.

E8-49. Research chemist, 8 years' diversified experience in pulp and paper manufacture. Resin formulation for paper treating and impregnating. Desires position of responsibility.

E9-49. Production manager or technical director. Past 3 years in new paper development work. Formerly asst. superintendent book and coated paper mill. Prefers paper product development work.

E10-49. Technical director. Employed in absorbent tissue mill. Desires broader opportunity. Particularly well experienced in bleaching, stock preparation, water treatment, boiler-feed water control.

E11-49. Paper mill management, general administration, production, and marketing, 47, married. Experienced as sales manager for bonds, converting papers, also operating manager for printing paper manufacturers.

E12-49. Chief engineer or asst. mgr. Twenty years' experience as plant engineer in pulp and paper industry. 40, college graduate. Familiar with all phases of construction, maintenance, mill layout, design, and operation.

E13-49. Chemical engineer, Clarkson Tech., 32, married. Experienced since 1933 as beaterman, back tender, chemist in tissue and kraft pulp mills.

E14-49. Chemist. Five years' experience in control and technical problems relating to groundwood and bleached and unbleached sulphate pulps and paper specialties.

E15-49. Chemical Engineer with wide acquaintance in the paper industry and presently employed as a Sales Engineer with Paper Converting Machinery Manufacturer, desires permanent responsible position. Age, 33, family, 10 years diversified experience in technical sales, research and development. Desirous of obtaining position as Manager of converting plant or Technical Sales allied with the paper industry.

E16-49. Superintendent or asst. supt. Twenty years experience on cylinder machines and all grades of boards. Can build a smooth running and efficient organization. Proven ability.

Note: Individuals who desire to make use of this service are requested to prepare their own statement of position desired, age, college training, industry experience. Use about 30 words. Most of the aforegoing notices were prepared from letters received. Hereafter notices will be published if received by the 15th of any month and will be repeated only if requested to do so.

Positions Open

P1-49. Chemist, paperboard production. New position to insure quality control. Applicant should have folding paperboard manufacturing experience and training in paper testing and analysis.

P2-49. Mechanical engineer experienced in papermaking. Age 30–50. Complete charge of mechanical operation. Capable man can become plant manager in a few years.

P3-49. Engineer-draftsman to take care of all engineering work in sulphate pulp and paper mill, including bleach plant.

P4-49. Young man under 30 for pulp sales work for large New York City distributor.

P5-49. Chief chemist. General pulp and paper mill background and sound technical training. To perform and supervise testing and control work. Man between 30 and 40 who might, within a reasonable time, assume full responsibility for manufacturing operations.

P6-49. Chief chemist, college graduate between 25 and 40, for paper mill and food container plant. Position leads to management as soon as individual can qualify.

P7-49. Graduate engineer for development work on corrugated containers and container testing at large corrugated box plant in Southeast. Several years experience in design, evaluation, and manufacture of corrugated containers required.

Note: The use of this department is open to pulp and paper and related companies desiring to obtain the services of operating executives, engineers, superintendents, and chemists. Machinery and commodity companies may use this space to find candidates for sales and service positions. Please prepare notice in the form in which is should appear.

BECCO HYDROGEN PEROXIDE

Make full use of

BECCO TECHNICAL CONSULTATION

Becco technical engineers have a wealth of knowledge and practical experience to bring to your bleaching requirements. Becco laboratories have accumulated a large amount of valuable data applicable to your problems.

Let this Becco service assist you in your mill bleaching of pulps whether of groundwood, sulfite, semi-chemical or mixtures. Write or call—at no obligation.

BECCO SALES CORPORATION

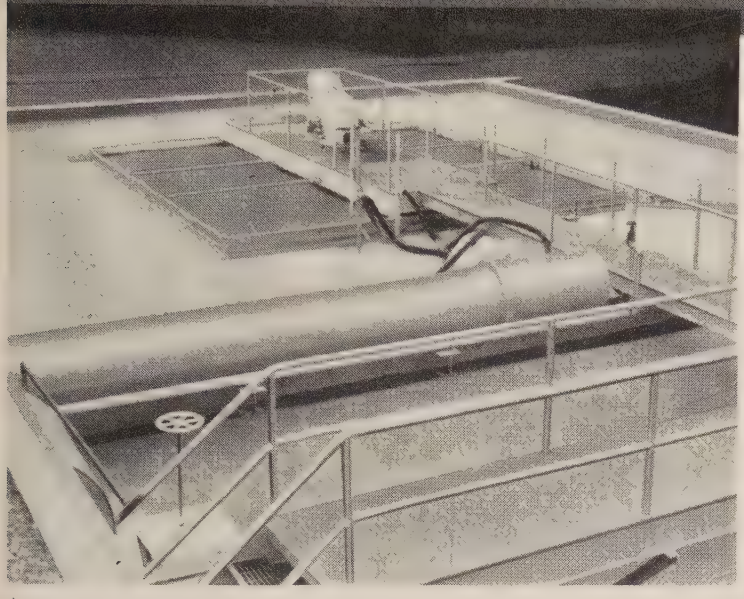
AGENTS FOR BUFFALO ELECTRO-CHEMICAL COMPANY, INC.

BUFFALO 7, NEW YORK

New York Boston Philadelphia Chicago Charlotte

PULP AND PAPER MILLS CAN

Save UP TO 80% IN SPACE



WITH THE COMPACT

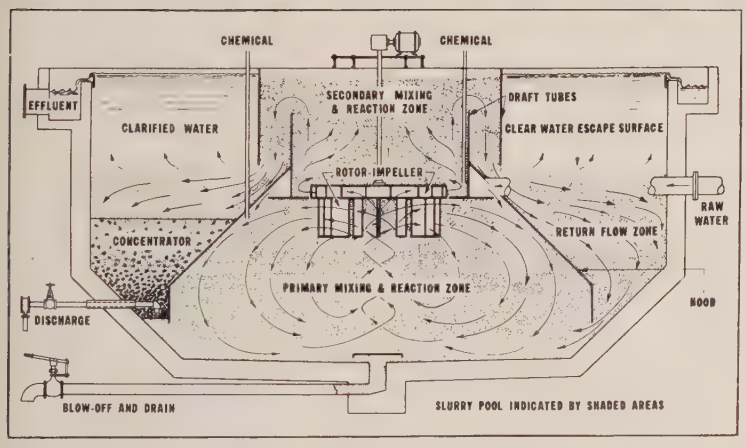
ACCELATOR®

The PREFERRED Water Conditioning Plant!

QUICK mixing, coagulating, settling, sludge removal . . *all* these steps are replaced IN ONE COMPACT UNIT by the ACCELATOR! Savings in space, up to 80%, are possible. Other superior advantages are, 1. Lower construction costs, 2. Simpler operation, 3. Faster chemical reaction, 4. Higher ratings, 5. An *exclusive* slurry recirculation feature which produces better, cleaner water in less time. Over 1100 ACCELATOR installations are now softening or clarifying almost ONE BILLION gallons of water every day! Without obligation discuss your water conditioning problem with our nearest field engineer.

A FEW OF THE MANY ACCELATOR USERS..

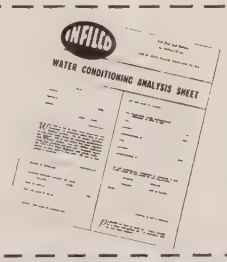
Auglaize Box Board Co., St. Marys, Ohio • Brunswick Pulp & Paper Co., Brunswick, Ga. • Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis. • Container Corp. of America, Pencoyd, Pa. • Dexter Sulphite Pulp & Paper Co., Dexter, N. Y. • Downingtown Paper Co., Downingtown, Pa. • Gulf States Paper Co., Tuscaloosa, Ala. • International Paper Co., Livermore Falls, Me. • International Paper Co., Panama City, Fla. • International Paper Co., Georgetown, S. C. • Kimberly-Clark Corp., Kimberly, Wis. • Kimberly-Clark Corp., Niagara Falls, N. Y. • Mead Corporation, Kingsport, Tenn. • National Container Corp., Jacksonville, Fla. • National Container Corp., Ontonagon, Mich. • National Container Corp., Tomahawk, Wis. • North Carolina Pulp Co., Plymouth, N. C. • Northwest Paper Co., Cloquet, Minn. • Rayonier, Inc., Fernandina, Fla. • St. Joe Paper Co., Port St. Joe, Fla. • St. Marys Kraft Corp., St. Marys, Ga. • St. Regis Paper Co., Deferiet, N. Y. • Scott Paper Co., Chester, Pa. • West Jersey Paper Mfg. Co., Camden, N. J. • Weyerhaeuser Timber Co., Longview, Wash. • Weyerhaeuser Timber Co., Springfield, Ore.



THE ACCELATOR

FREE LABORATORY SERVICE . . SEND FOR THIS WATER CONDITIONING ANALYSIS SHEET!

Make sure your water meets the exacting specifications you require. Send for our Water Analysis Sheet, then fill in and return it with a sample. You will receive our laboratory analysis and report promptly. A valuable INFILCO CHEMICAL CALCULATOR slide rule sent FREE to all who return our analysis sheet properly completed. *No cost or obligation is involved for this laboratory service.*



INFILCO

• BETTER WATER CONDITIONING AND WASTE TREATMENT SINCE 1894 •

INFILCO INC.

GENERAL OFFICES: 325 WEST 25th PLACE • CHICAGO 16, ILLINOIS

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WORLD'S LEADING MANUFACTURERS OF WATER CONDITIONING AND WASTE TREATING EQUIPMENT

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Ohio

Herbert A. Smith, Recording Secretary of the Ohio Section, reports that from the standpoint of attendance, good programs, and interesting discussion the 1948–49 season has been the most satisfactory one to date. Attendance at the March meeting reached 120, an all-time high.

On January 15, at the Manchester Hotel in Middletown, Ohio, Harry Williamson of Englewood, N. J., talked on "Stock Preparation and Its Effect on Formation." This meeting was held jointly with the Miami Division of the Superintendents Association.

After a few brief introductory remarks, Mr. Williamson began his discussion by outlining the four major steps in making a sheet of paper. They were: first, selection and proportion of the different pulps in the furnish (which also includes the mechanical conditions necessary to develop the pulps). Second, the evacuation of the liquid and formation of the fibers. This requires that the fibers be kept in a homogeneous state, that is, where one cubic inch is the same as another. Third, evaporation of the surplus moisture, and fourth, finishing operations.

Mr. Williamson reviewed the mechanical developments of the fourdrinier and cylinder machines. He recalled that in 1927 the double head-box was developed for making special grades on the fourdrinier machine. On the fourdrinier machine, formation is achieved by holding the fibers in suspension in water until they are interlocked, to form the sheet. The shake helps to keep the water on the wire until the fibers are put into a criss-cross formation by this shaking motion that causes the fibers to bump into one another. Consistency of the stock in the head-box should never be over 0.5%, and best formations are obtained at lower values. On a cylinder machine, best formation is obtained at a consistency of 0.1 to 0.2%, while using the proper mesh wire.

There are four important factors to consider in making a sheet of paper. They are: (1) long fibers, which are the reinforcing steel rods in the paper, (2) short fibers, which are the bricks and mortar, (3) slow stock, and (4) fast stock.

In Mr. Williamson's ideal paper mill, he would have a separate refining system for each different type of fiber (sulphite, soda, and kraft) that he expects to use. These pulps would be separately refined to 90% of their inherent value before blending in the beater. By inherent value of a pulp, he meant the point where maximum Mullen is developed without too great a falling off of Elmendorf. Also, where fold and stretch are at their peak. Going beyond this point, one will get again a hard brittle, low tear sheet.

The speaker recalled some of his experiments in which he developed a highly hydrated pulp by subjecting it to high pressure. This gave a glassine type sheet in all appearances, but the strength (tear and burst) were about the same as that of the raw fibers. In other words, beating (mechanical treatment) is the only way to develop the strength of a pulp.

More recently Mr. Williamson has conducted a series of experiments in which a cylinder mold, one-foot wide, was so constructed that a sheet of paper was formed on the mold under a predetermined pressure. Different tests were performed on a variety of pulps in which each pulp was refined a definite extent, then formed on the cylinder at a standard pressure. The speed of the cylinder was run at increasing speeds until the centrifugal force prevented the fibers from sticking to the mold. Then similar experiments were tried on the same pulp that had been refined to 100% of its inherent value. Thus, the maximum speed at which the cylinder could be run and still form a sheet of paper was determined for each different type of pulp.

At present a larger cylinder, 72 inches in width is being built, but instead of using pressure, suction will be utilized. Speeds as high as 3000 feet per minute are a possibility.

General Discussion: The following problems were discussed after the talk.

Fuzz: Mr. Williamson commented that fuzz occurs when a greater force is applied to the fibers than the cohesive force that is holding the fibers together. If a sheet of paper is sticking to the first press or fuzzing in the driers, the pulp usually has not been refined enough. Soda pulp is one pulp that cannot be hydrated to any great extent, therefore, if a sheet contains any large amount of soda pulp, and is fuzzing, either the amount of soda pulp will have to be reduced or the longer fibered pulps will require more refining.

Question: What would you do if you had a machine chest full of pulp that was not refined enough, that is, the stock was too fast, and no additional refining could be done to the pulp? The weight of the paper was O.K., and so was the strength, but the formation was bad.

Mr. Williamson: Slow the paper machine down a few feet. This will give the fibers a longer time to form on the wire. The general statement, Slow up for fast stock and run away from slow stock, is true when dealing with variations of ten feet or so in speed.

This statement met with a difference of opinion among several of the papermakers present; no doubt a good many factors and conditions should be known to qualify the above statement.

On Feb. 15, 1949, Duncan S. Brown, General Manager, Lockland Div., Gardner-Richardson Co. talked on "Calender Stack Finishes as Applied to Paperboard and Folding Box Boards." Dr. Brown's remarks follow:

One of the main reasons for using a waterbox on a board calender stack is to obtain a surface property on the board by a more economical method and often with better results, than by doing it in the beater. The calender finishing of board imparts surface smoothness, lays fuzz, gives a shine, makes for a better printing surface and adds color.

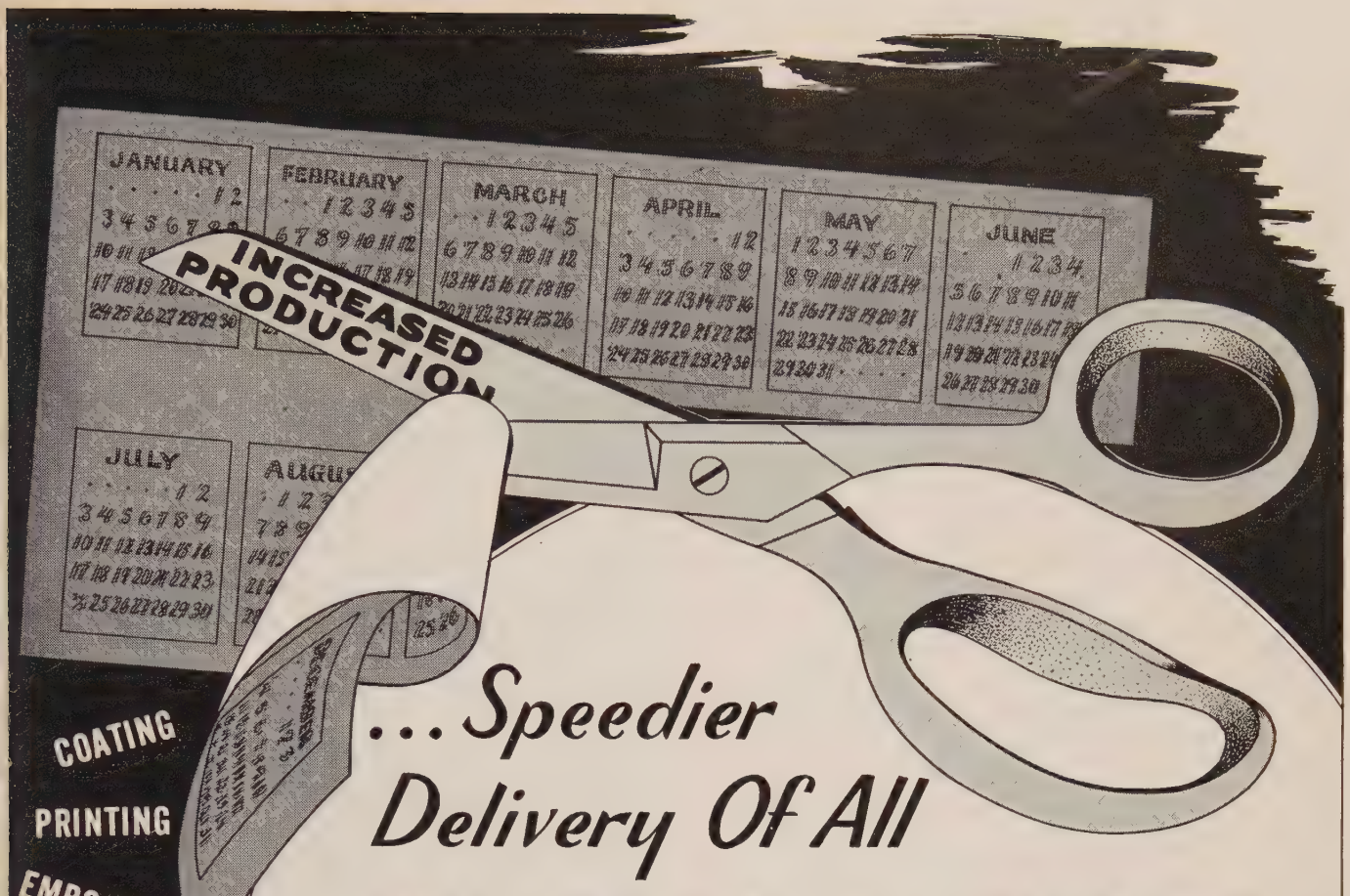
Water and starch are the two most common materials used. Most starch solutions are enzyme-converted or chlorinated to obtain low viscosities. However, some thick starch solutions are used for making the board somewhat grease resistant, especially if it is to be printed by gloss inks.

When printing board with gloss inks it is desirous to treat the surface of the board to reduce the penetration of the oil vehicle into the board and thus have the ink stay on the surface and dry by oxidation to a glossy shine. Various materials are being used to obtain this condition or property of the board and these include: (1) starch and protein, (2) methylcellulose, (3) Kelgin, (4) PLF calender size, and (5) PVA (poly-vinyl alcohol).

Various operating troubles maybe encountered with calender sizing, for example: too much foaming, too viscous a solution, sticking and gumming of the calender rolls, and calender wrap due to slime spots and holes in the board.

Another desirous property imparted to surface treated board is that of water resistance. An example of this is

(*continued on page 48 A*)



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... Speedier Delivery Of All

WALDRON MACHINES

It doesn't seem so long ago when we, along with other machinery manufacturers, were forced by conditions to make customers wait from 18 months to two years for delivery of their orders. Today, thanks to the better supply of materials and component parts along with our own greatly enlarged facilities, new tools and sharply increased production, we have licked the delivery problem. WALDRON Machines are now regularly being built and delivered in one-half or less the time required a year ago. Nothing could give us greater satisfaction than being able to insure this greatly improved service to our customers—old and new.

Delivery time estimates which might have been submitted prior to July 1948 can and should be revised. We would welcome an opportunity to submit a revised delivery date based on our new, speedier delivery schedules.

JOHN WALDRON CORP.

Main Office & Works – NEW BRUNSWICK, NEW JERSEY

BUILDERS OF QUALITY MACHINES SINCE 1827

(*continued from page 46 A*)

sign board used on the front of street cars. Wax emulsions have proved very effective in meeting this severe sizing requirement. However, wax sizes make the board so resistant to water that ordinary glues will not hold, especially in laminating operations. Some of the newer resinous glues are doing a better job, but even these are not perfect.

Grease and oil resistance is still another property that is of value when the board is used to package greasy and oily materials. Silicate is the cheapest material used to obtain grease resistance but makes an inferior board as compared with glassine or special laminated grades.

Another purpose of treating board on the calender is that of coloring. This operation is used to obtain a surface appearance by a cheaper method than dyeing in the beater. The depth of color can be varied from a slight tint to a deep brilliant shade. Dyeing the stock somewhat in the beater is followed in addition to coloring at the calender, especially in obtaining some of the brilliant and deep colors.

The advantages of calender coloring are: (1) economy, (2) brilliance of shades, and (3) some of the newer dyestuffs can be used to better advantage. However, there are some disadvantages, and they are listed as follows: (1) reduced light fastness, (2) tendency to bleed more with water (except when alcohol-soluble dyes are used), and (3) there may be a difference in dye take-up across the deckle of the board, which is usually due to moisture and formation variations.

Some boards are treated with flameproofing reagents to reduce fire hazards. Silicates also make the surface of boards resistant to rub.

Boards are usually sold on a weight basis and quoted according to the gauge-list finished. There are four different finishes for any given caliper. These are No. 1, 2, 3, and 4 with No. 1 having the roughest surface and No. 4 the smoothest. Weight variations of no more than 10% are tolerated.

The speaker next discussed some of the mechanical setups of calender stack equipment and operation. First, is the equipment needed to prepare the various solutions. Pumps are required to supply the solutions to the calender or in the case of gravity-feed to return it to the supply tank. Finally come the water boxes which are usually made of wood or metal, and vary in width from a foot to two inches. The water box acts as a retainer to allow the solution to run onto the roll and up to the nip.

Some of the variables affecting the surface sizing of board for water resistance are: (1) surface of the paper or porosity, (2) use of wetting agents in sizing solutions, (3) condition of calender rolls, (4) weights applied to calender rolls, (5) position of water boxes (top or bottom of stack), and (6) moisture in the board.

Moisture can be applied to board by steam sprays or moisture vaporizers. Frequently two regular steam driers are placed between two calender stacks.

If the board comes too dry from the machine, the properties of the board may be destroyed somewhat when it is wet again at the calender.

There are always two water-boxes, one to treat the top side and one for the bottom, otherwise there would be a severe curl to the treated side. This is just the opposite to the effect on paper since it curls away from the wetted side.

Considerable trouble occurs with corrosion and/or pitting of the cast iron calender rolls. The causes of this are attributed to a build-up of an acid-sizing solution due to leaching of alum from the board, and a constant rusting action of the calender roll.

To stop this, the size solutions are buffered with certain salts, and corrosion resistant surfaced rolls have been tried. These seem to last for a while but then go bad. Alloyed-steel rolls have been tried, but have not proved to be the entire answer.

Following Dr. Browns' talk, the following questions were asked:

Don Goodman (*Sorg*): When you are coloring at the calender, do you use a slack sized board?

Dr. Brown: The board is usually sized less than an ordinary writing paper. If the board is too strongly sized, wetting agents are used. A drop of water will spread-out instead of soaking into a board that has been treated with a wetting agent.

Howard E. Ellis (*Sorg*): How does high temperature drying of the board effect its take-up of solution?

Dr. Brown: If the board becomes case-hardened there will be considerable variation in the take-up of solution.

Walter J. Cassiday (*Sorg*): How far can you go with temperatures and steam pressures before case-hardening occurs?

Dr. Brown: Case hardening is determined by visual inspection of the board. If the board is in contact with 15 to 20 driers at 240°F., high pressure steam can then be applied without developing case-hardening.

Jerry Moyer (*Champion*): If the board is over dried, and then given a heavy water finish, will this hurt the strength of the board and its sizing (water resistance)?

Dr. Brown: No.

Ed. Brandon (*Howard Paper Mills*): How can you prevent foaming of the calender sizing solution?

Dr. Brown: Three steps: (1) Select materials that don't foam, (2) Have a mechanical setup that doesn't work air into the solution—no high speed pumps, avoid vortex in water box overflow return, and (3) Use foam-killers. Care should be exercised in using foam-killers as they may destroy the property desired in the board or impart odors, as does kerosene.

Don Goodman: Do you put the water boxes on the first stack, followed by one or two other stacks?

Dr. Brown: That is the usual practice, however, when using methocel, the application is at the finishing stack as methocel is soluble in cold water and not hot, and it is therefore necessary to cool the board before treating it with this particular solution.

Howard E. Ellis: What about slippage in the calender stack?

Dr. Brown: This is a factor to be considered. Soft rolls develop more friction, which is helpful in getting a smoother surface.

Phil S. Cade (*Harding-Jones*): What is the per cent moisture pick-up when using two water boxes?

Dr. Brown: About 4% when treating a slack sized board and 2–2.5% when treating a moderately size board.

On Thursday evening, March 10, at the Manchester Hotel, there was a panel discussion on Coating. O. W. Callighan of Edgar Bros. Co., Kalamazoo, Mich., presided as moderator. The members of the panel were J. R. Simpson, Champion Paper & Fibre Co., Hamilton, Ohio, and B. E. Sooy, Gardner-Richardson Co., Middletown, Ohio.

Mr. Callighan briefly reviewed the various types of machine coating and conversion coating operations from an historical point of view. He also enumerated the developments and improvements in coating raw materials that were required with each step in the advancement of new and better coating equipment.

Mr. Simpson described briefly the typical installation of the Champion knife-edge machine coating process. The coating-color make-up equipment consists chiefly of a 400-gal. starch cooker with conventional agitation. A 600-gal. clay mixer of the Whiz-type agitation, and a storage tank for the finished color.

The coater is very simple and consists of an applicator roll that revolves in a pan of the coating-color applying an

(*continued on page 50 A*)

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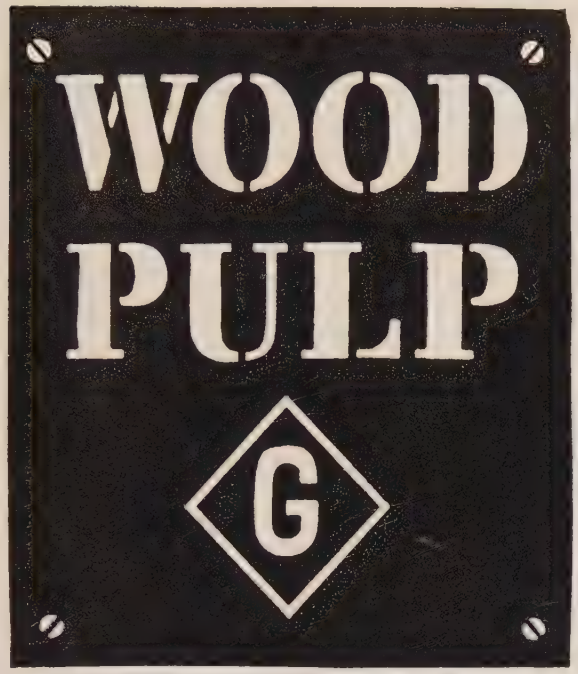

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(*continued from page 48 A*)

excess amount to the paper and using a knife-edge to remove the excess.

At the present time there are (exclusive of the Champion mills) 26 paper machines using the Champion type coater and 14 others in process of installation. When these are in operation they will be used to make the following grades of paper:

	Installations
Bread wrapper	2
Book	12
Board	23
Blanks	2
Bag	1
Total	40

Mr. Sooy challenged those present to be aware of two major dangers in regards to machine coating: First, Resist progress and second, Complacency.

The District of Columbia Paper Co. patented a process in 1927 that was the forerunner of machine-coating applications. They were using an engraved roll to apply a pattern to the sheet. They did not develop this method any further to apply it to machine-coating.

Today there are three major coating methods: (1) The Champion Process whereby an excess of coating is applied

Ohio TAPPI Meeting, Hotel Manchester, Middletown, Ohio, Thursday, March 10, 1949

and then doctored off, (2) Imprinting methods whereby metered coating is deposited on imprinting rolls and thence to the paper, and (3) The Air-knife coater, whereby an excess of coating is applied and the excess blown off by an air knife.

Mr. Simpson has described the Champion Process and I need not say any more about it. The John Waldron Syncroset coater is an example of the second method. The good points are as follows: (1) It is simple, (2) It can use high solids, (3) It can run at high speeds, (4) It is automatic, (5) It is partly flexible, and (6) It is uniform. The coat-weight applied runs about 2 to 2.5 pounds per 1000 sq. ft. or 8 to 9 pounds per ream (25 × 38—500). The disadvantages are: (1) It is limited as to amount of coat weight, (2) It has a high installation cost, and (3) It has a high maintenance cost.

There are now four installations of the John Waldron Air-knife coater. The good points are: (1) It is inexpensive, (2) It has a wide range of coat weights, (3) Its maintenance cost is low, (4) It can run high solids of 55%, (5) It has no coating pattern, and (6) It can run at high speeds—1000 ft. per min. for off machine coating. The disadvantages are: (1) There is no experience with on the machine coating, and (2) It is difficult to dry high-coat weights.

Ohio TAPPI Meeting, Hotel Manchester, Middletown, Ohio, Thursday, March 10, 1949

Left to right: (front row) S. R. Holmes, Gardner-Richardson Co., J. R. Simpson, Champion Paper & Fibre Co., B. E. Sooy, Gardner-Richardson Co., Olin W. Callighan, Edgar Bros. Co., Moderator of Panel; (back row) H. A. Smith, Recording Secretary, Phil S. Cade, Chairman, Art Thurn, Vice-Chairman, Bob McCarron, Treasurer.

The following questions were discussed.

1. Does machine coating slow down the machine very much?

Ted Sooy: No, unless you go to high coat weights.

2. What effect does machine coating have on the bending qualities of box board?

Ted Sooy: This depends on how heavy a coat weight is being applied. Thin coat weights are all right. The type of process used is also a factor.

Jim Simpson: I agree with Ted, however, a coated board will usually crack on bending more than an uncoated one. The board furnish must also be considered.

Ollie Callighan: The degree of scoring has considerable influence on the cracking tendencies of box-board.

E. K. Stilbert: The use of Rubber Latex as a coating adhesive or extender improves bending qualities of board.

O. R. Steffens: I agree with Jim and Ted. Certain modified starches and the use of plasticizers aid bending qualities of coated board.

3. What is the maximum number of coaters that have been installed on any one machine so far?

Jim Simpson: Two coaters; some will soon have three. This will give the sheet additional quality.

J. B. Chamberlain: We have more than two Champion-type knife coaters on our machines.

4. Will coat-weight change with change of draw?

Jim Simpson: Run the sheet loose, more coat is retained on sheet; tighten the draw and more coat will be scraped off. We find it best to run a snug draw or one gets a more pronounced coating pattern.

5. Have any mills quit *off the machine* coating and gone to machine coating because it is of equal quality?

Jim Simpson: I know of two that have done so.

Harry Pedley: We went to machine-coating kraft bag stock because of reduced labor and coating costs and improved flexibility. Besides our conversion equipment was about ready to be replaced. It was worn out.

6. Can machine-coating be applied on both sides of the sheet without drying between coats?

O. W. Callighan: Yes, one process applies the coating on both sides without drying each application.

7. Is it possible to make colored grades by any machine coating process?

Ted Sooy: It can be done if there is sufficient demand.

Harry Pedley: We have made a machine coated bag stock using canary chrome-pigment as the dye.

(*continued on page 52 A*)

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(*continued from page 50 A*)

Jim Simpson: I have seen the difficult blue-grey coating color applied by machine-coating with good results.

8. What types of adhesives are used in machine coating?

O. R. Steffens: Starches, casein, soybean protein, alpha protein, and latex plus starch.

Elmer Stilbert: Casein plus dextrin and starch plus dextrin.

9. Can all adhesives be adapted to all machine coating process?

Elmer Stilbert: That is hard to say. Thixotropy comes into play when dealing with high solids-color and this may limit the type of adhesive used.

N. R. Gotthoffer: A special low viscosity soybean protein coating color of 55% solids is being used.

Jim Simpson: In machine coating board, casein is the principal adhesive used because it can be easily water-proofed, and this is important because most boards are treated after coating at the calender with water boxes. Alpha-protein works as well as casein in this respect. Starch can be water-proofed but it is more costly and of doubtful over-all end use at present.

Elmer Stilbert: Starch and latex as the adhesive have not been tried for coating board. Some may have tried it, but to date we have no information.

10. Is there any reason why an air brush coated card should blacken more than a brush coated sheet when calendered?

Ted Sooy: If the same coating-color is used there will be no difference. The air-brush may be superior in this respect because generally you don't have to calender it as much to get a smooth finish.

11. Is there any difference in the wax pick test of a brush coated sheet vs. air brush coated one?

Tom Luey: No difference.

Jim Simpson: As the run progresses the air brush coated sheet will have a lower pick test as the air brush classifies the clay particles, with a resultant build-up of the larger particles in the color and hence more of them staying on the sheet and consequently lower pick. Steps are being taken to correct this condition by using finer clays and better make-down methods.

12. How do the best machine coating compare to best converted No. 1 Enamel? Halftones, etc.?

Jim Simpson: Machine-coating on board is equal to off-the-machine coating as to printing results.

O. W. Callighan: The machine coated product of today will duplicate nearly every converted sheet excepting a No. 1 grade of book or litho paper.

13. How many rolls are there in a Waldron Syncroset Coater?

O. W. Callighan: Generally speaking 2 or 3 trials must be made on different rolls before the correct type for a given sheet will be found. One roll with all conditions being known might pick up 3 pounds per side where 8 pounds is needed, therefore a different roll is necessary.

14. What can be done to smooth the sheet prior to coating board, where the Champion process is used?

Jim Simpson: The type of rawstock means everything. Usually there is a set of smoothing rolls before the second set of coaters. These rolls are water cooled to prevent sticking, single nip, steel or chrome plated rolls. Pressures at nip up to 100 pounds per linear inch. Diameter of bottom roll 14 inches and top 12 inches. Moisture in sheet going to coater 40–45%.

15. What is the moisture content in the sheet before machine coating?

Jim Simpson: In coating board, going to the first set of coaters it is 50–55% dry; and going to second sheet of coaters it is 60–65% dry.

Ted Sooy: In coating paper the sheet is dry, with only 5–6% moisture.

Jim Simpson: In answer to a previous question, if the machine is operating at maximum drying capacity, and machine coating is installed, the first coater will slow down machine speed 3–5%, and if a second coater is installed the over-all speed will be slowed down 7–10%.

16. Is blowing (the separation of the plys) a problem?

Ted Sooy: Yes, blowing is a problem but it has to be solved in the beater-room or at the jordans.

17. To install the Champion process do you have to remove any driers?

Jim Simpson: Usually not. On stack-drier board machines, the coater can be installed between the stacks. With three tier driers the bottom drier is removed. This gives room for a smoothing press prior to the coating application.

18. Has the Champion coater been used for other types of coating, for example, greaseproof sheet?

Jim Simpson: Yes.

Maine-New Hampshire

During the recent annual TAPPI meeting, the Executive Committee of the Maine-New Hampshire Section met and decided to hold the Spring meeting at the Wentworth-by-the-Sea, Portsmouth, N. H., on Friday and Saturday, June 17 and 18, 1949.

This is the first time a regular meeting of the Section has been selected in New Hampshire and the Wentworth has adequate facilities and is an ideal location for a TAPPI gathering. Located near Portsmouth on the island of New Castle, the Wentworth-by-the-Sea has its own 9 hole golf course of over 3000 yards, an ocean water swimming pool, and a separate pool containing salt water heated to 72°F. The Saturday noon luncheon will be held on the shore and will be an old-fashioned clam bake (weather permitting).

The committee consisting of J. J. Thomas, S. D. Warren Company, and George Day, Brown Company, as chairman will arrange the technical program for Friday afternoon and Saturday morning. A program is also being arranged for the ladies attending the meeting.

The committee on arrangements includes J. J. Thomas, S. D. Warren Company; F. B. Lincoln, Jr., Hollingsworth & Whitney Company; W. D. Stroud, F. C. Huyck & Sons; with J. F. Wright, National Aniline Div., Allied Chemical & Dye Corp. as chairman.

Delaware Valley

The April 28 meeting of the Delaware Valley Section will feature a panel discussion on testing practices in the mills of this region. A questionnaire has been sent to all Section members to find out what tests are being used. The purpose of the meeting is to show how each mill's testing program compares with other mills in the Valley.

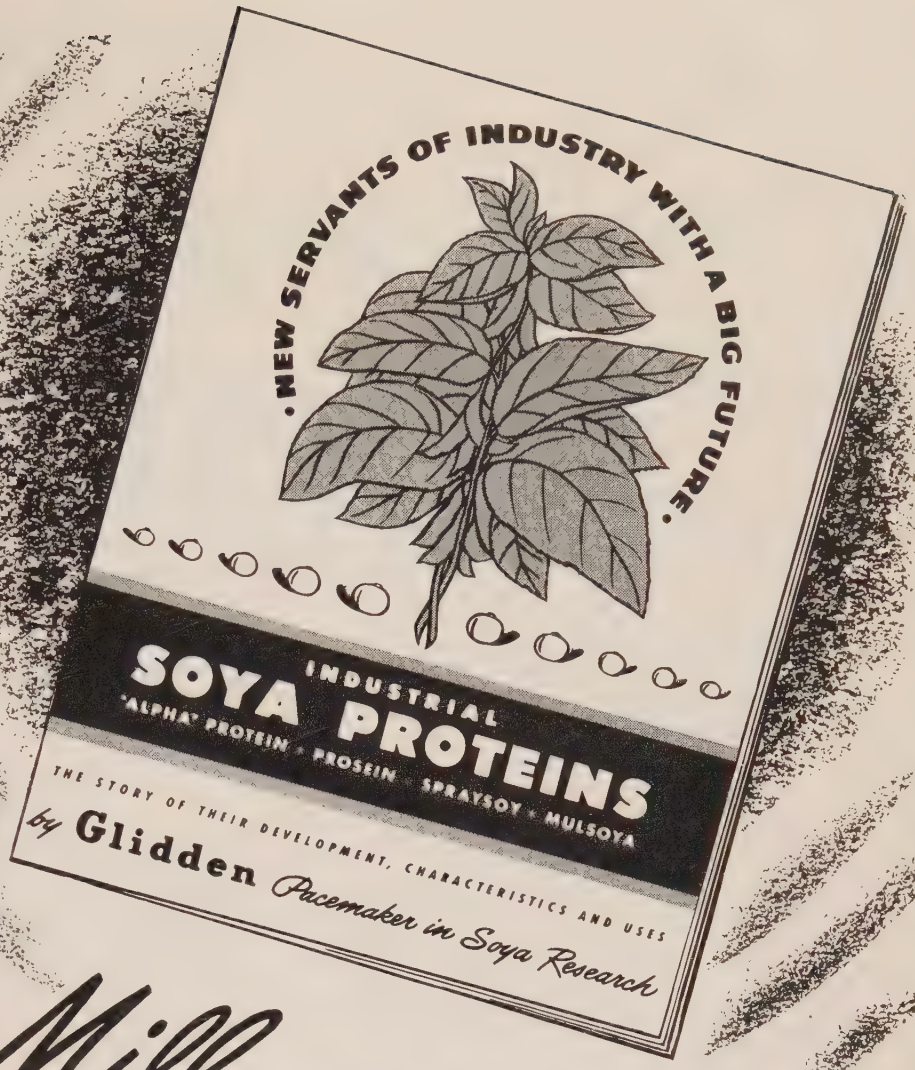
At the March 24 meeting Prof. Herman Mark of the Polytechnic Institute of Brooklyn gave a talk on "Recent Progress in Cellulose Research."

At the January 27 meeting Elmer K. Stilbert of the Dow Chemical Co., Midland, Mich., discussed "The Development of Latex as a Paper Coating Adhesive." John P. Weidner of the Container Corp. of America presided as chairman and August Erspamer of the P. H. Glatfelter Co. led the technical discussion.

Mr. Stilbert summarized his remarks, as follows for this issue of *Tappi*:

"The word 'latex' has generally been associated with the milky sap from the rubber tree, *Hevea brasiliensis*. Due to the physical resemblance of synthetic polymer dispersions to

(*continued on page 54 A*)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(*continued from page 52 A*)

natural latex, they became known even in the very early days as 'synthetic latices.' Today many such products are being produced and are commonly differentiated from natural latex only by the name or number.

"Early work on the use of a latex as a paper coating adhesive was done with natural rubber latex since it was the only product available in quantity at the time. The initial properties of the coated paper were very interesting and desirable, but a few months of natural aging showed failure of the coating due to oxidation of the rubber.

"About the same time, work on synthetic latices resulted in the development of Neoprene and Acryloid. Although they possessed interesting adhesive properties, they were of little interest to the paper coating industry at the time because of their cost.

"Synthetic latices developed slowly and primarily for special uses until World War II when government and industry combined efforts to produce large quantities of synthetic rubber to replace natural rubber. Toward the end of the war, as the demand for the synthetics waned, the industry began searching for new uses. By this time the picture had changed completely, since the low cost of the styrene-butadiene latices, produced for the government, opened up markets that had never even been considered previously.

"One of the features in the manufacture of synthetic latices is the ability to vary the chemical components to obtain different properties in the resulting polymer. Such variations from the original synthetic rubber composition have become of considerable commercial importance since the war.

"Of the many latices that have been evaluated for use as paper coating adhesives, only Dow Latex 512K has been found to have all of the properties required for a paper coating adhesive. Some of the more important of these are: mechanical stability, compatibility with other coating ingredients, stability of the polymer to aging, color stability, and reasonable cost.

"Early work on synthetic latices at Dow was concentrated on styrene and butadiene because of their availability and low cost. Of the hundreds of experimental formulas made, 512 latex proved to be more generally useful so work was concentrated on it. This latex deposited a soft, flexible, elastic film. The initial evaluation work revealed that it was compatible with drying oils, varnishes, resins, and water soluble binders such as starch, glue, casein, etc. It exhibited excellent pigment-binding properties, both alone, and in combination with other materials.

"After preliminary laboratory work on coated papers, a few cooperative coated paper manufacturers in the Kalamazoo area were approached. Their initial work proved that 512 was a very desirable modifier in coated paper. Unfortunately, it was not mechanically stable enough to withstand plant processing. Encouraged by the enthusiasm of the mill management for the properties of the coated paper, the problem of stability was immediately put to the reasearch laboratory. Very shortly thereafter, Dow Latex 512K was developed. Fairly complete property data was obtained on this product and made available in a bulletin called 'Dow Latex 512K for Clay Coated Papers.'

"The interest in Dow Latex 512K spread quickly through the off-machine coated paper industry. Since the same materials are also used in the wallpaper, decorative wallboard and coated paperboard industries, interest was quickly aroused in these industries also. Although much development and technical service work has been related to these other fields the major emphasis has been on the manufacture of pigment coated printing papers. At first, this work was naturally concentrated on methods of using Dow Latex 512K in the various coating processes with the wide range of coating materials commonly used in the industry. As more and more information was accumulated, the emphasis shifted to the improved properties that could be obtained in the many grades of coated paper supplied to the printing industry.

"The next logical step was to contact the printer. Plans in this direction were recently formulated and several special bulletins have already been supplied to printers and large users of printing. Although thousands of tons of coated paper have been made with 512K latex and printed without difficulty, it has been found that very few printers are aware of the fundamental differences in the properties of the paper and the reason for them. Advances in the art of printing require close cooperation with both the ink maker and the printer. It is, therefore, desirable to discuss Dow Latex 512K and its effect on the properties of printing papers with these people at every opportunity."

New England

The March 18 meeting of the New England Section was held at Toto's in Smith Ferry, Mass. John Bainbridge, of the Merrimac Div., Monsanto Chemical Co., presented a paper prepared by William S. Wilson of the same Company on "Why Size Paper." T. A. Martone of E. I. du Pont de Nemours Co., Inc., discussed "The Use of Reduced Vat Dyes." The remarks of these speakers will be published later in *Tappi:*

The annual converting meeting of the Section was held in Holyoke, Mass., at the Roger Smith Hotel on Friday, January 21.

The main portion of the meeting consisted of a panel discussion on the subject of Paper Saturation led by Robert H. Mosher of the Holyoke Card & Paper Company, Springfield, Mass. For the formal part of the presentation, the panel consisted of three speakers, Ralph T. Nazarro of Premoid Products, Inc., W. Edward Higby of the General Latex & Chemical Co., and J. J. Uber of Texon, Inc. A brief resumé of the formal papers presented during the meeting are given below and will be published at a later date in *Tappi.*

Dr. Higby's paper on the subject of "Latex Saturants" was wide in scope and covered the subject of the desirable properties of paper for saturation as well as the various saturants which are available, along with data on their properties and requirements for their formulation.

Dr. Nazarro followed Dr. Higby on the subject of "The Theory of Saturation" and discussed the desirable properties of a saturant from the theoretical standpoint. In his talk, Dr. Nazarro also discussed fiber-resin bonds and the properties necessary in a saturant to obtain maximum properties in the saturated paper.

Mr. Uber completed the program with a discussion of the saturation of papers as an integral part of the actual papermaking operation. The fiber formulations commonly used as well as desirable conditions for stock preparations and the peculiarities of machine operation when handling resin and rubber saturated papers were all thoroughly covered.

At the completion of the formal portion of the program, an open discussion was held during which various questions presented from the floor were discussed by one or more of the speakers. For this portion of the program, three additional men joined the panel to assist the other speakers in thoroughly covering the field. These men were Roger Bascom and Roger Stellar of B. F. Goodrich Chemical Co., and George Schmid of Cellutin Corp. A spirited discussion of more than an hour was held and the panel was able to answer in a satisfactory manner practically all of the questions presented.

(*continued on page 56 A*)

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(continued from page 54 A)

Kalamazoo Valley

On February 3 the Kalamazoo Valley Section met at the Columbia Hotel in Kalamazoo, Mich. There were only about forty present due to a genuine Michigan blizzard that was in progress. Willis Van Horn of the Institute of Paper Chemistry, Appleton, Wis., gave a very interesting talk on "Fish or Factories—Can We Have Both?" Following this talk there was a panel discussion led by Jack Gilman of the Allied Paper Mills. Associated with him were Dwight E. Stocker, Michigan Paper Co., James A. Wise, Kalamazoo Paper Co., and Anthony Palledino, resident engineer for the National Council on Stream Improvement.

Dr. Van Horn said, in part:

"Current interest in stream pollution is but one manifestation of the fact that our Country is approaching its saturation point from the standpoint of population. Biologists predicted that the United States would reach its normal maximum population in about 1960. The units of any normal population compete with each other for the use of the available natural resources, among which are the streams and rivers, and this competition becomes more severe as the population approaches or passes its normal maximum. As the population grows, people become more and more aware of the circumstances of their environment—in the current situation the stream pollution problem.

"At the present time, we have a large industrial economy based on the use of streams, sometimes to their detriment. When the country was younger and the population less dense, these conditions, in many instances, were unnoticed, but as the population grew more and more people became aware of them. The pulp and paper industry is a case in point. It must have a large and economic source of water, without which it cannot exist. There is no question that such use of water may depreciate its use for other purposes. The pulp and paper industry has recognized its responsibility in this respect and has made great strides in solving its problem. Much remains to be done, however, and while the task presents many difficulties, the industry confidently expects to place itself in a position where it can use the water without causing grounds for reasonable complaint."

On Thursday evening, March 3, 1949, the Section held their last formal meeting of the year and the subject of the evening was "Graphic Arts." The April and May meetings will not be held this year since the Kalamazoo Valley Section of TAPPI and the National TAPPI are jointly sponsoring the National Coating Meeting at Grand Rapids, Mich., on April 26 and 27.

The meeting was attended by approximately 100 men. D. R. Erickson, consulting chemist, introduced George Zupanic, manager of the printing department, Upjohn Co., Kalamazoo, Mich. Mr. Zupanic gave a very good discussion of the problems the printer runs into that are caused by paper. He emphasized the advantages of close contact between technical service departments in the mill and the printers. He also told of the time and money lost by folded sheets, poor resistance to picking on the presses, uneven coatings across the sheet, off-square sheets, lumps in coating, moisture content, feather edges in the middle of the ream, insufficient opacity and damage to sheets by poor packing and shipping.

Following Mr. Zupanic's discussion Hugh Smith of the Kalamazoo Vegetable Parchment Co. was introduced. He had small models of aniline and gravure presses on hand which he demonstrated. He discussed the limitations and advantages of the two types of printing and told about some of the differences in ink composition between the two processes.

Mr. Erickson then discussed the problem of heat-set inks on high speed letter press printing. He stated the main problem on heat set inks is the loss of strength of the paper between colors. The heat that must be added to dry the inks reduces the strength to a point where the papers will tear in the next press or operation. He suggested the possibility of plastizing the paper so that the water would not be given up too readily. He emphasized the fact that tearing strength was the most important physical strength property.

Pacific

To encourage the presentation of papers by men who are not in a position to assemble sufficient material for a formal paper, the Pacific Section of TAPPI has been devoting one meeting a year to short papers. In February, 1948, the meeting covering "Practical Laboratory Gadgets and Procedures" was very successful in bringing about the exchange of much useful information on mechanical techniques. A similar meeting, this time featuring Non-Standard Methods, was held at the University of Washington in Seattle on Jan. 18, 1949. Nine papers in all were presented.

The meeting was convened at 2:15 p.m. by Chairman Harold C. Wall. After a brief business session the program was turned over to E. Gray King, the moderator of the panel. Dr. King outlined the program and indicated that questions and discussion should follow each paper when presented.

The program was as follows:

1. Estimation of the Relative Molecular Size of Lignin Sulphonic Acids by Vincent F. Felicetta, Pulp Mills Research, University of Washington.
2. Description of a Laboratory Chip Screen by Gordon Curzon, Puget Sound Pulp & Timber Co.
3. Preparation and Drying of Large Pulp Hand Sheets by Harold Brown, Weyerhaeuser Timber Co.
4. Fir-Tex Freeness Tester by L. R. Sherlock, Fir-Tex Insulating Board Co.
5. Non-Standard Methods of Analysis at Soundview Pulp Co. by Sidney Silverstone, Soundview Pulp Co.
6. The Determination of Per cent Reduction in a Kraft Pulp Recovery Furnace by S. P. Strayer, St. Regis Paper Co.
7. Determination of Hydrogen Sulphide in Stack Gases by R. C. Gilardi, Camas Div., Crown-Zellerbach Corp.
8. Use of the Beckmann Flame Spectrophotometer in Pulp Mill Analyses by J. E. Jeffery and A. Tratnick, Rayonier, Inc.
9. Ink Test for Butcher Papers Using Bausch and Lomb Opacimeter by P. T. Dickie, Camas Div., Crown-Zellerbach Corp.

After the technical session the group adjourned to the Edmond Meany Hotel for a social hour followed by dinner. Dr. Raymond B. Allen, President of the University of Washington, gave a very timely and instructive talk on his activities in Washington, D. C., during the past summer when he was a member of the Committee on the National Military Establishment setup as a part of the Hoover Commission to study the workings of the executive branch of the United States Government.

The next meeting of the Pacific Section was held at Longview, Wash., on April 12. The Shibley Award papers were given at that time.

H. C. Wall, Chairman of the Section appointed the following to serve as members of the Publications Committee: R. M. True, Chairman, General Dyestuff Corp., Portland, Ore.; E. O. Erickson, Puget Sound Pulp & Timber Co., Bellingham, Wash.; Joseph L. McCarthy, University of Washington, Seattle, Wash.; Walter F. Holzer, Crown-Zellerbach Corp., Camas, Wash.; and E. Gray King, Rayonier, Inc., Shelton, Wash.

Lake States

Supercalenders and rewinders were discussed by E. E. Thomas, of the Appleton Machine Company, before the

(continued on page 58 A)

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(continued from page 56 A)

Lake States Section at the monthly dinner meeting in Appleton on February 8. This description of modern equipment was followed by the presentation of two movies which showed the newest supercalenders and rewinders in operation.

Mr. Thomas noted that recent advancement in the design of supercalenders was due primarily to the demands of machine coated paper field for higher speeds, greater widths, better control of variables, and minimum down time. Before the war supercalendering was carried on at speeds of 500 to 800 feet per minute and with pressures of 500 to 800 pounds per inch in the bottom nip. New stacks operate at 2000 feet per minute with pressures of 1200 to 1400 pounds per inch in the bottom nip. Mr. Thomas told how these requirements have been met and he emphasized the present freedom of the operator from adjustment duties through the use of centralized and precision control of the stack and its electric drive. Mr. Thomas described the corresponding improvement in rewinders through centralized control and the employment of hydraulic and pneumatic adjustments.

The fluorescence microscopy of wood and paper was described by Ralph O. Marts, of the Forest Products Laboratory, at the dinner meeting of the Lake States Section, on March 8 in Appleton. Mr. Marts told about the preparation, examination, and photomicrography of specimens and showed more than fifty slides, many of them in color, which illustrated the application of his technique to specimens of wood and paper.

The light from a carbon arc is filtered so that the near ultraviolet light passes through a special quartz condensing system to the specimen surface to be examined. This ultraviolet light causes the emission of visible fluorescent light by the specimen. The fluorescing surface of the specimen is viewed or photographed through ordinary microscope optics and a suitable filter. Marked color contrast is obtained because of the different intensity and color of the fluorescent light from the various structures and constituents of the specimen. Mr. Marts noted and illustrated even better color contrast in some cases through the use of congo red and other dyes as stains. Some aspects of the specimens which could not be seen by other methods were thus made visible. The contrast between fibers and urea and phenolic resins in paper was noted.

Chicago

On January 17 Harry Weston, Associate Secretary-Treasurer of the Superintendents Association, conducted a quiz program in which he presented the biographies of several prominent executives of the industry. The members of the Chicago Section were asked to identify these individuals. On the same program William R. Zwecker, consulting engineer of Chicago, gave an interesting report of his recent trip through Europe.

On February 14 Lou Pohner of the Lithographic Technical Foundation discussed the use of the Hunter Reflectometer and J. P. Thompson of the General Electric Company discussed the use of the G.E. Spectrophotometer.

The March 21 meeting was devoted to a panel discussion of Coating and Laminating Adhesives. Participating in the panel were E. B. Osborne, technical service engineer, B. F. Goodrich Chemical Co., who talked on "The Application and Use of Geon Latices in the Paper Industry," C. E. Fawkes, Secretary of Pyroxylin Products, Inc., who discussed "Coatings and Hot Melts," and J. C. Dean, Socony-Vacuum Oil Co., who talked on "Petroleum Laminates and Coatings."

Empire State

The Empire State Section is continuing to hold its monthly meetings at Niagara Falls, Watertown, Glens Falls, and New York City. Since the groups meeting at these places are independently organized they have the appearance of being local sections within themselves. They are, however, branches of the Section and will all meet together on June 2–4, 1949, at the Hotel Sagamore, Bolton's Landing, Lake George, N. Y., for the annual meeting. Foster P. Doane of the Sandy Hill Iron & Brass Works is taking care of the arrangements.

On March 17 at the Village Inn, South Glens Falls, N. Y., C. L. Clark of Clark & Vicario Co., New York, N. Y., discussed "The Application of Vacuum Pumps in the Paper Industry."

The Western New York Group met at the Prospect House, Niagara Falls, N. Y., on March 9. George H. Rand, International Paper Co. presided and E. S. Skinner of the Beloit Iron Works, Beloit, Wis., gave an illustrated lecture on the latest improvements in Fourdrinier paper machine design.

On March 10 the Northern New York Group met at Gene's Inn, Glen Park, N. Y. H. A. Spencer of Knowlton Bros., Inc., Watertown, N. Y., presided and introduced R. M. Drummond of the International Paper Co., Glens Falls, N. Y., who talked on "Mill Control."

The Western New York Group met at Niagara Falls on April 13. Russell Shearer, manager of the Merritton, Ont. Div., Alliance Paper Mills talked on "Modernization of Old Paper Machines."

The Metropolitan Group met on January 11 at Fraunces Tavern, New York City. Brig. Gen. L. O. Grice, Commander of the New York Q.M.C. Purchasing Office, talked on "Quartermaster Requirements, Operations, and Policies."

On March 8 the Metropolitan Group again met and participated in a symposium on "The Mating of Paper and Ink." Milton Zucker of the International Printing Ink Co. presided as moderator and four members of his staff discussed letterpress, offset, gravure, and aniline printing.

outstanding improvement in DIAPHRAGM VALVES by CRANE

NEW SEATING ARRANGEMENT MORE DURABLE... SAFER... MORE EFFICIENT

WORKING PRESSURE:
150 Pounds
water, oil, air or gas
180 Deg. F.
maximum temperature

The many outstanding advantages offered by new Crane Diaphragm Valves stem from basic improvements of the usual design. On Crane valves, the disc and diaphragm are separate. Each has but one function to perform, which helps to assure safer, more efficient, longer-lasting valve performance. Look over these exclusive Crane features.

1. LONGER DIAPHRAGM LIFE, because diaphragm is used *only* to seal the bonnet—not for seating purposes.

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5. EASIER OPERATION—Crane separate disc and diaphragm construction takes less torque—fewer turns—to operate.

USUAL DESIGN

Diaphragm is used both to pinch off flow and to seal bonnet. Is subject to severe crushing against bridgewall, and rapid wear at point of seating. When diaphragm fails, valve can't be closed.

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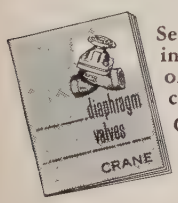

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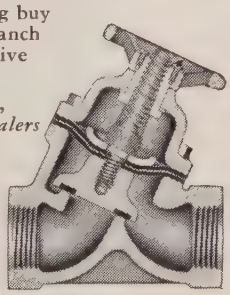
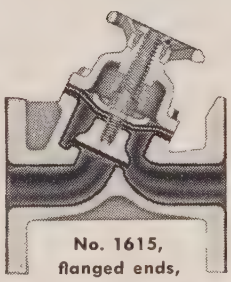
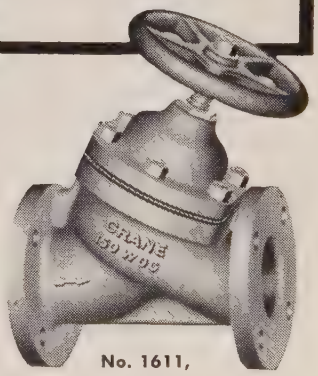


No. 1610, screwed ends



No. 1615, flanged ends, neoprene coated



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New TAPPI Members

John R. Arnold, Assistant to Groundwood Superintendent, Escanaba Paper Co., Escanaba, Mich., a 1943 graduate of Purdue University.

Stephen R. Arnold, Laboratory Supervisor, Westfield River Paper Co., Russell, Mass., a 1943 graduate of Reed College.

Robert B. Blakeslee, Chemist, Imperial Paper & Color Corp., Glens Falls, N. Y., a 1935 graduate of University of Cincinnati.

Gordon K. Bonham, Chemist, Coos Bay Pulp Corp., Anacortes, Wash., a 1943 graduate of the University of Washington.

Ralph M. Buechler, Sales Engineer, Black-Clawson Co., Hamilton, Ohio, a 1939 graduate of Purdue University.

Bernard M. Center, Engineer, Frederick L. Smith, Consultants, New York, N. Y., a 1940 graduate of Cooper Union.

Alfred P. Coha, Student, New York State College of Forestry, Syracuse, N. Y.

Adam Cunningham, Chief Engineer, Price Brothers & Co. Ltd., Kenogami, P. Q., Canada, a 1928 graduate of the University of Edinburgh.

Eugene De Luca, Assistant Superintendent, Fraser Companies Ltd., Newcastle, N. B., Canada, a 1937 graduate of the University of Toronto.

Warren F. Douglass, Chief Chemist, Pope & Gray, Inc., New York, N. Y., a 1938 graduate of Pratt Institute.

George H. Eick, Technical Representative, National Southern Products Corp., New York, N. Y., a 1948 graduate of Brooklyn Polytechnic Institute.

Louis A. Elbl, Plant Superintendent, Sealright Co., Inc., Kansas City, Kans., a 1936 graduate of the University of Kansas with an M.A. degree.

Richard J. Grimm, Chemist, St. Regis Paper Co., Deferiet, N. Y., a 1949 graduate of Seton Hall.

Walker Hamilton, Jr., Chemist, Riegel Paper Corp., Milford, N. J., a 1948 graduate of University of Pennsylvania with an M.A. degree.

Edwin A. Hanna, Superintendent, Pulp Preparation, Scott Paper Co., Chester, Pa.

Lester F. Herman, Sales Engineer, Fulton Iron Works Co., St. Louis, Mo., a 1932 graduate of Pennsylvania State College with an M.S. degree.

Eric R. Heuser, Control Engineer, Long Lac Pulp & Paper Co., Terrace Bay, Ont., Canada, a 1945 graduate of McGill University.

Hugh T. Holland, Assistant Chemist, International Paper Co., Chisholm, Me., a 1947 graduate of the University of Maine.

William L. Ingmanson, Graduate Student, The Institute of Paper Chemistry, Appleton, Wis., a 1945 graduate of Tufts College.

John C. Hyatt, Student, New York State College of Forestry, Syracuse, N. Y.

John F. Jahne, Chemist, Newton Falls Paper Mill, Inc., Newton Falls, N. Y., a 1948 graduate of New York State Agricultural & Technical Institute.

Louis S. Keyser, Research Chemist, Rayonier, Inc., Shelton, Wash., a 1938 graduate of the University of Illinois with a Ph.D. degree.

Donald H. Kincaid, Research Supervisor, Minnesota & Ontario Paper Co., International Falls, Minn., a 1927 graduate of Queen's University.

Morse R. Kinne, Student, New York State College of Forestry, Syracuse, N. Y.

Richard J. Krueger, Student, New York State College of Forestry, Syracuse, N. Y.

Kenneth C. Logan, Director of Development, Northeastern Paper Products Ltd., Quebec City, P. Q., Canada, a 1933 graduate of British Columbia College.

Frederick H. MacLaren, Group Leader, Standard Oil Co. (Indiana), Whiting, Ind., a 1925 graduate of Ohio State University.

Robert B. MacMullin, Consulting Chemical Engineer, R. B. MacMullin Associates, Niagara Falls, N. Y., a 1920 graduate of Massachusetts Institute of Technology.

James H. McClure, Manager, Coating Mill, St. Regis Paper Co., Kalamazoo, Mich., a 1938 graduate of Washington and Lee University.

William K. Metcalfe, Secretary, J. O. Ross Engineering Corp., New York, N. Y., a 1936 graduate of Geneva College, Colorado University.

Jacques V. Mockel, Director of Research and Control, S. A. Fabélta, Brussels, Belgium, a 1930 graduate of University of Brussels.

Lewis G. Neubauer, Chemist, Dept. of Scientific and Industrial Research, Wellington, N. Z., a 1939 graduate of University of New Zealand, with an M.Sc. degree.

Hugh C. Osborn, Paper Chemist, R. T. Vanderbilt Co., Inc., E. Norwalk, Conn., a 1948 graduate of Clarkson College.

Robert S. Painter, Chemist, New York & Pennsylvania Co., Inc., Lock Haven, Pa., a 1948 graduate of Bucknell College.

Albert A. Pavlic, Sales Technologist, Ammonia Dept., E. I. du Pont de Nemours & Co., Wilmington, Del., a 1938 graduate of the University of Wisconsin with a Ph.D. degree in 1942.

John H. Pearson, Control Engineer, Shartle Bros. Machine Co., Middletown, Ohio.

Gordon Petrie, Sales Representative, Black-Clawson Co., Hamilton, Ohio, a 1943 graduate of Oregon State College.

Leonard A. Pierce, Jr., Bleach Plant Foreman, St. Regis Paper Co., Bucksport, Me., a 1938 graduate of Bowdoin College.

John W. Pontius, Assistant Chemist, Certain-teed Products Corp., Marseilles, Ill., a 1948 graduate of Eureka College.

Henry B. Pratt, Jr., Assistant Chief Construction Engineer, Union Bag & Paper Corp., Savannah, Ga., a 1932 graduate of Worcester Polytechnic Institute.

Charles M. Rosser, Technical Superintendent, Sylvania Div., American Viscose Co., Fredericksburg, Va., a 1930 graduate of Wabash College with a Ph.D. degree from New York University in 1935.

Charles S. Russell, Assistant Superintendent, Coating Dept., S. D. Warren Co., Cumberland Mills, Me., a 1938 graduate of University of Maine.

Ralph R. Shaw, Librarian, U. S. Dept. of Agriculture, Washington, D. C.

Allyn R. Skelton, Technical Representative, American Cyanamid Co., New York, N. Y., a 1947 graduate of the University of Minnesota.

(*continued on page 62 A*)

TRAYLOR KILNS

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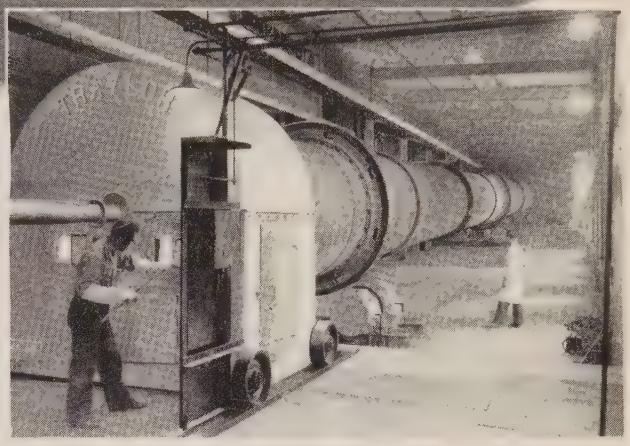
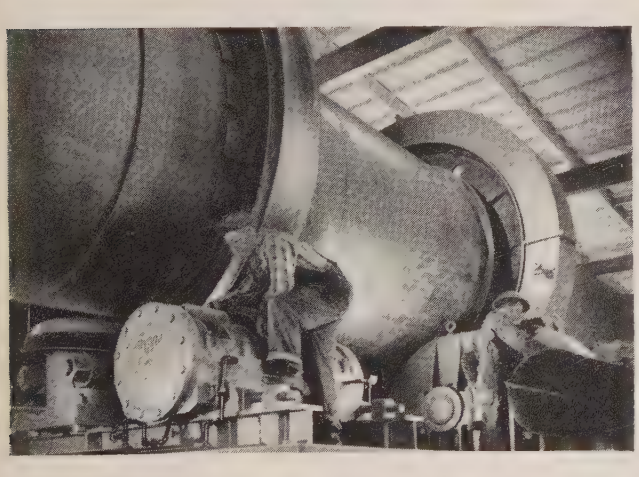
Because they are fitted *exactly* to the individual conditions of each installation, with *all* controls grouped at a single, convenient station . . . efficient thermo-processing of sludge to lime, the critical point in profitable pulp production, is assured by Traylor Kilns. Traylor's long experience in this special field means that a Traylor installation is *your* best bet for profitable operation.

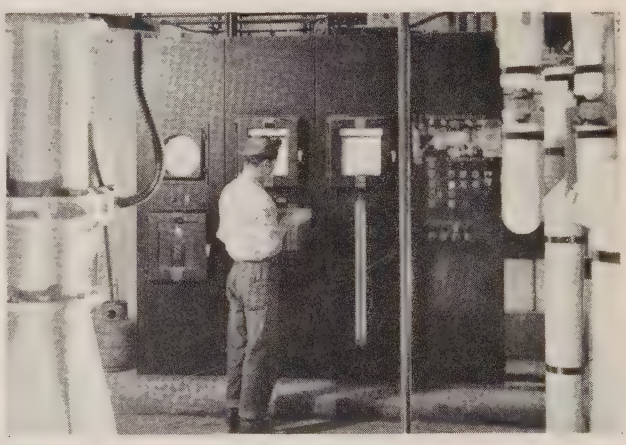
Write today for full information.



A typical Traylor installation in the Pulp and Paper Industry is this 250′ x 7′ Rotary Kiln at Weyerhauser Timber Company's plant in Longview, Washington.



Only routine checking and servicing are necessary to maintain perfect operating conditions for this kiln. Note heavy proportions of the single roller support and thrust roller.



Every condition within the kiln is recorded and controlled at this central station. Product quality is kept consistently high and uniform.

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10th & Mill Streets, Allentown, Pa.

Sales Offices: New York, N. Y., Chicago, Ill., Los Angeles, Calif.

Canadian Mfrs: Canadian Vickers, Ltd., Montreal, P. Q.

(continued from page 60 A)

Karl B. Steenberg, Professor, Royal Institute of Technology, Stockholm, Sweden, a 1944 graduate of the University of Stockholm, with a Ph.D. degree.

Roger L. Steller, Technical Sales Representative, B. F. Goodrich Chemical Co., Cleveland, Ohio, a 1940 graduate of Ohio State University with an M.S. degree from The Institute of Paper Chemistry in 1942.

Harry M. Sutcliffe, Chemist, Northern Regional Research Laboratory, Peoria, Ill., a 1935 graduate of Colorado Agricultural College.

Donald E. Tessier, Production Manager, Fonda Container Co., Inc., St. Albans, Vt.

Charles L. Tomlinson, Technical Assistant to Pulp Mill Superintendent, Howard Smith Paper Mills Ltd., Cornwall, Ont., Canada, a 1941 graduate of Bishop's University.

Jesse H. Trask, General Superintendent, St. Regis Paper Co., Little Falls, Minn.

Arthur S. Wells, Division Engineer, The Mead Corp., Kingsport, Tenn., a 1914 graduate of Cornell University.

John C. Wood, Vice-President in Charge of Manufacturing, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich., a 1922 graduate of the University of Michigan with an M.S. degree in 1923.

David R. Wright, Jr., Junior Technician, Champion Paper and Fibre Co., Canton, N. C., a 1947 graduate of North Carolina State College.

TAPPI Directory Changes

Louis Bailey, formerly with Stadler, Hurter & Co., is now service engineer for E. F. Houghton & Co. of Canada, Montreal, P. Q.

Geoffrey Beall, formerly of the Preston Laboratories, is now statistician in the research department, Swift & Co., Union Stock Yards, Chicago, Ill.

Harold V. Brady, formerly of the Ryegate Paper Co., is now vice-president, Negley Bag & Paper Co., San Antonio, Tex.

James B. Brown, formerly of the Crown Zellerbach Corp., is now technical supervisor, Western Waxed Paper Co., North Portland, Ore.

Richard S. Buckley, formerly of the Rochester Paper Co., is now chemist for the Mohawk Paper Mills, Inc., Cohoes, N. Y.

John B. Calkin has been appointed director of the Dept. of Industrial Cooperation and associate professor of chemical engineering at University of Maine, Orono, Me.

Charles W. Cassell, formerly technical director, John Strange Paper Co., is now superintendent of power and maintenance, Everett Pulp and Paper Co., Everett, Wash.

Wilbur L. Cassiday, formerly with W. R. Grace & Co., is now manager of quality control, Alton Box Board Co., Alton, Ill.

James T. Coghill, formerly of the Consolidated Machine Tool Co., is now vice-president and chief engineer, Curlator Corp., Rochester, N. Y.

C. William Converse, formerly of the Valley Iron Works Co., is now sales engineer, Sprout, Waldron & Co., Muncy, Pa.

Charles N. Egan, formerly of the Hennepin Paper Co., is now with the Little Rapids Pulp Co., West De Pere, Wis.

J. J. Forsythe is now technical superintendent, International Paper Co., Niagara Falls, N. Y.

Robert P. Goodale has recently been made sales manager of the paper resin and chemical group, Rohm & Haas Co., Philadelphia, Pa..

Donald J. Goodman is now asst. technical director, Sorg Paper Co., Middletown, Ohio.

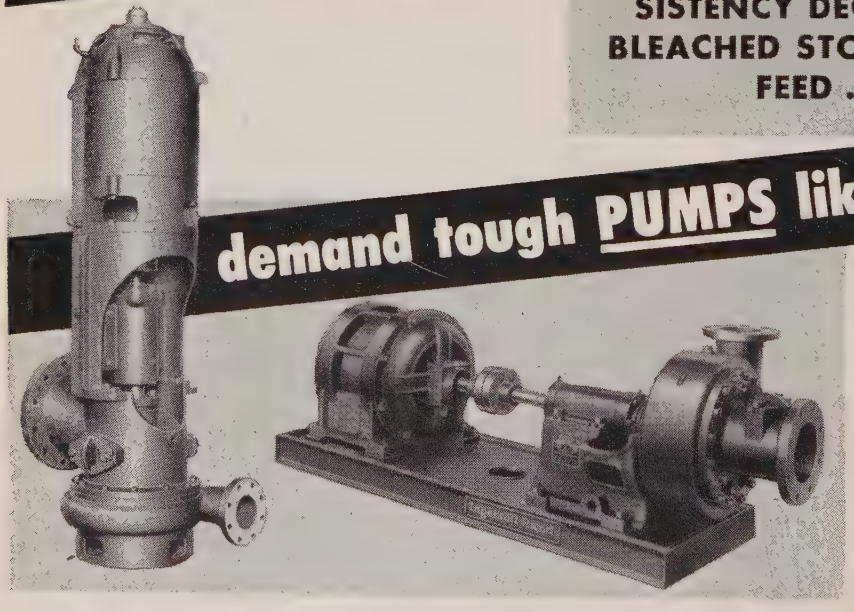
Walter Hall, formerly of the Kingsport Div., Mead Corp., is now steam and power engineer at the Chillicothe, Ohio, mill.

(continued on page 64 A)

tough stock-moving jobs like these . . .

. . BULL SCREEN . . BLOW PIT . . BROWN STOCK . . HIGH CONSISTENCY DECKERED STOCK . . HEAVY BLEACHED STOCK . . BROKE . . MACHINE FEED . . COUCH PIT, etc.

demand tough PUMPS like these . . .



The ability of Ingersoll-Rand pumps to handle the many stock-moving jobs in paper mills has been thoroughly proven . . . *in actual service.* They're tough — they stay on the job — and with a minimum of maintenance.

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Let an I-R engineer tell you about the features of these vertical and horizontal stock pumps. Ask for your copy of Bulletin 7022 describing the complete line of I-R pumps for pulp and paper mills.

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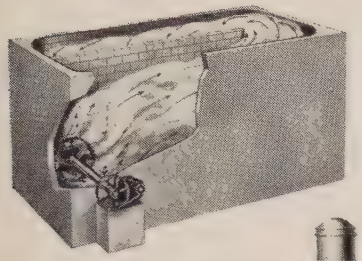
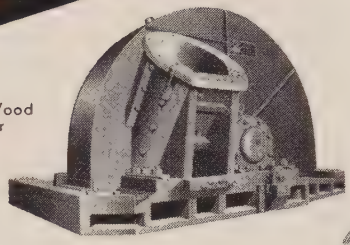
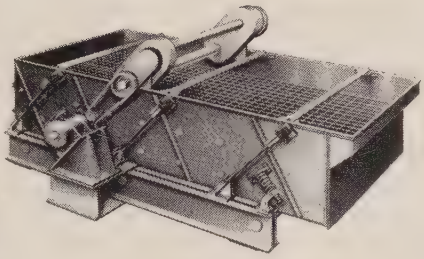
Illustrated are some of the better known MURCO Papermill and Woodroom equipment that for years has successfully served the paper industry . . . each machine being improved year after year as operating conditions demand more and more production. Complete information on this equipment—or any other Papermill or Woodroom equipment that you may be planning—will be sent you upon request.

Horizontal Axial Flow Agitator

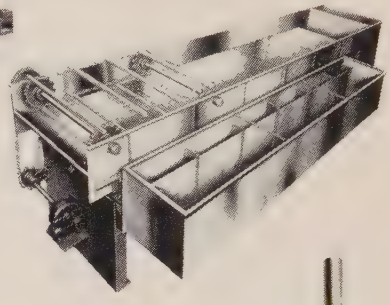


Pulp Wood Chipper

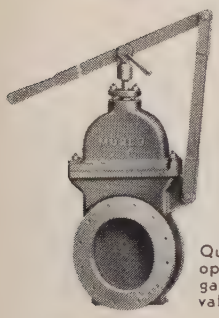




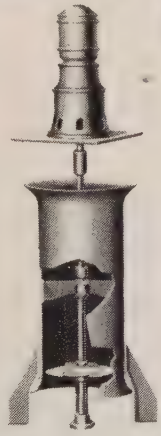
Level vibrating double deck chip screen.



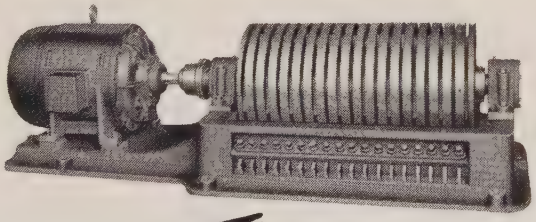
Stainless Steel Flat Screen



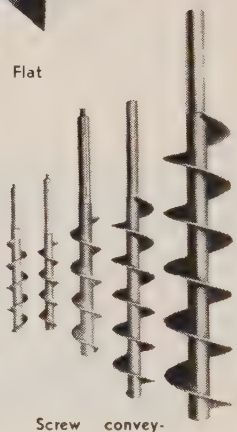
Quick opening gate valve



Vertical Axial Flow Agitator



Chip Crusher



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MURCO Stainless Steel Fabricated Blow Pipes, Stock Lines and Fittings offer substantial savings—in less shut down time, low maintenance, easy installation and extremely long life.

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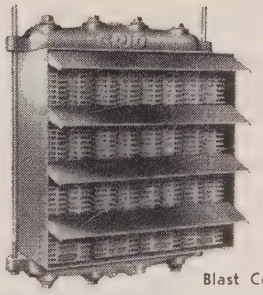
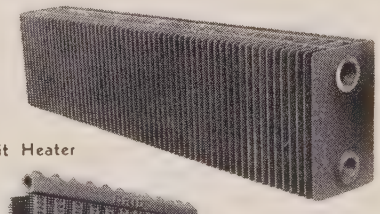
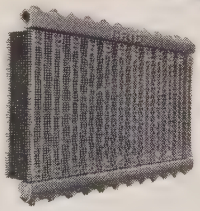


Blast Coils



Unit Heater



"FIN" Heating Sections made in one piece.

D. J. MURRAY MANUFACTURING CO. WAUSAU WISCONSIN

(continued from page 62 A)

Ward D. Harrison, manager of production, Riegel Paper Corp., is now located at Milford, N. J.

Frank J. Hoar is now president and treasurer, G. D. Jenssen Co., Watertown, N. Y.

K. Helge Holm, formerly of the Barrett Div., is now chemist for the Fernstrom Paper Mills, Pomona, Calif.

Robert A. Lemieux, formerly of the Hercules Powder Co., is now technical sales representative for Anheuser-Busch, Inc., St. Louis, Mo.

Donald W. Libby, formerly of the Oswego Falls Corp., is now chemist for the Solvay Process Div., Syracuse, N. Y.

C. Stewart Macnair, formerly of C. S. Macnair Associates, is now consultant in product development, Acme Steel Co., Chicago, Ill.

William McIntosh, Jr., formerly of the Union Bag & Paper Corp., is now vice-president of the Southern Corp., Savannah, Ga.

Carl Magnus, formerly consulting engineer, is now superintendent, Moraine Paper Co., W. Carrollton, Ohio.

James F. Maguire, formerly of Electro Technical Products, Inc., is now director of purchases, General Felt Products Div., Standard Cap and Seal Co., Brooklyn, N. Y.

Frank Makara is now practicing patent law at 155 E. 44 Street, New York, N. Y.

Arthur F. Martin is now manager of the Virginia Cellulose Research Div., Hercules Experiment Station, Wilmington, Del.

John C. Meiler, formerly of the Plywood Research Foundation, is now doing development work for the Coos Bay Lumber Co., Coos Bay, Ore.

S. C. Nagel, formerly of the Lauxite Corp., is now chemist for the Monsanto Chemical Co., Springfield, Mass.

Edgar M. Pierce, formerly of Alonzo B. Reid, Inc., has established the Pierce Consulting Engineering Co., 583 Atlantic Ave., Boston, Mass.

Albert S. Quinn is now vice-president, Stebbins Engineering & Mfg. Co., Seattle, Wash.

William A. Robinson, formerly of Cia. Ind. de Antenquique, is now with Fibreboard Products, Inc., E. Antioch, Calif.

Michael Shenk, formerly of Peerless Adhesive Co., is now chief chemist, Atwood Adhesive Co., Seattle, Wash.

Ulf G. Soderlund, formerly of the N.Y.S.C.F., is now a trainee, Oxford Paper Co., Rumford, Me.

Vernon L. Tipka, formerly of the Bird Machine Co., is now engineer for the News Print Service Bureau, New York, N. Y.

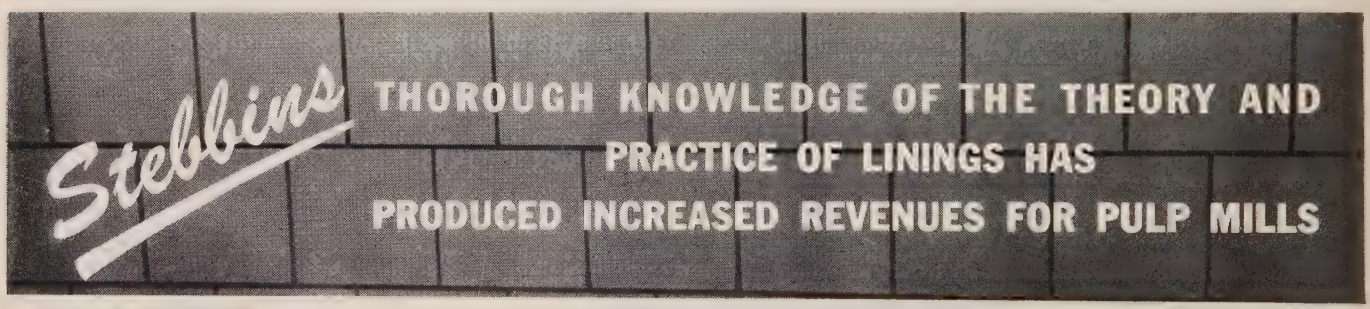
Harris O. Ware, technical service engineer, Hercules Powder Co., has been transferred from Kalamazoo, Mich., to Wilmington, Del.

Frederick Wierk, consulting engineer, Great Neck, N. Y., received the Stevens Honor Award Medallion at the 79th Annual Stevens Inst. of Technology Dinner in New York on February 18. Mr. Wierk's citation read: "For notable achievement in the fields of process plant design and Naval Air station design." Just before the War Mr. Wierk served as chief engineer in charge of design of the U. S. Naval Air Station at Quonset Point, R. I., the world's largest undertaking of its kind. At this time he designed the building structure generally referred to as the Quonset Hut.

Arthur M. Worthington, Jr., formerly of the American Tissue Mills, is now paper mill chemist for the Champion International Co., Lawrence, Mass.

D. M. Yost is now technical director, the Sorg Paper Co., Middletown, Ohio.

R. S. Roeller has succeeded R. C. Bigelow as official representative of the Pennsylvania Salt Mfg. Co. in the Technical Association.



NEW processes and improved operation in pulp manufacture is largely dependent upon the ability of the linings of the various vessels, tanks, chests, etc., to permit of long time dependable service.

Stebbins has pioneered the linings used in the leading pulp cooking processes:

Calcium Base
Ammonium Base
Magnesium Base

The correct lining is one of the best investments you can make when rebuilding or installing new digesters, chests, tanks, accumulators, etc., in a pulp mill. Dependable operation pays dividends year after year.

UNITED STATES PATENTS ON PAPERMAKING

Fourth Quarter, 1948

Compiled by CLARENCE J. WEST

The following list of patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the Gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture.

Copies of any of the following patents can be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired.

The previous lists of patents for 1948 appeared in *Paper Trade Journal* 126, No. 17: 59–60 (April 22, 1948); 127, No. 6: 55–57 (Aug. 5, 1948); and *Tappi* 32, No. 2: 37, 38, 40, 42 (1949).

October 5, 1948

2,450,419. Compartmented container. John H. Cassidy and Reed M. Grunden, assignors to The Hinde & Dauch Paper Co., Sandusky, Ohio. Filed May 18, 1943. 6 claims. (Cl. 229-15.) A knockdown container is provided with a partition member which is detachably secured in the container and is held in place by means of interior side-wall flaps.

2,450,558. Single blank container for paper sheets. Oscar H. Ogren, Rockford, Ill. Filed Sept. 20, 1944. 10 claims. (Cl. 229-16.) The invention relates to a container for a loose-leaf memorandum pad.

2,450,573. Folding box. Earl Barber, assignor to Angelus Paper Box Co., Los Angeles, Calif. Filed May 13, 1946, 5 claims. (Cl. 229-41.) A folding carton has a bottom and foldable sides and ends, each of which is unscored to render it substantially rigid, and lateral foldable tabs on each ends, with means for maintaining the carton in its folded and open conditions, selectively.

2,450,681. Apparatus for coating fiber insulation board. Carl G. Muench, assignor to The Celotex Corp., Chicago, Ill. Filed Oct. 4, 1943. 1 claim. (Cl. 91-55.) An apparatus is described for applying a liquid coating to a sheet of board, followed after drying with a second coat; moisture is then applied and the surface is smoothed and ironed with a heating means.

2,450,786. Wall covering and method of applying same. Albert G. Ferguson, assignor to American Associated Co., Inc., Atlanta, Ga. Filed Aug. 15, 1944. 1 claim. (Cl. 20-4.) Board is covered with sized cotton linters and then with wall paper.

2,450,801. Composite partitioning and spacing element and combination thereof with a container. Joseph G. Huye, assignor to Huye Space Saving Box System, Inc., New Orleans, La. Filed March 19, 1945. 6 claims. (Cl. 229-15.)

2,450,838. Paper pulp screen. Wilfred F. Mathewson, Weymouth, Mass. Filed Jan. 26, 1945. 13 claims. (Cl. 92-35.) The screening means consists of two parallel walls separated by a small clearance space which is of sufficient size to permit the fine acceptable portion of the unscreened pulp to pass through; means are provided periodically to flush the clearance spaces to remove unacceptable material.

October 12, 1948

2,450,900. Machine for forming articles from a liquid slurry. John D. Lyall, assignor to Armstrong Cork Co., Lancaster, Pa. Filed April 23, 1943. 10 claims. (Cl. 92-54.) This patent relates to an apparatus for forming mineral wool boards.

2,450,901. Method of treating liquid slurries to separate fibers from heavier particles. John D. Lyall, assignor to Armstrong Cork Co., Lancaster, Pa. Filed April 30, 1943. 6 claims. (Cl. 209-159.) A method is claimed for the removal of undesirable heavy particles from a mixture of mineral wool, paper pulp fibers, and asphalt emulsion.

2,450,941. Shipping, storage, and display cartons. Walton B. Crane, assignor to Alpak, Los Angeles, Calif. Filed Aug. 25, 1943. 8 claims. (Cl. 229-27.) A container can be divided into upper and lower tiers by utilizing a die-cut divider without interfering with the functions of the longitudinal and transverse partitions.

2,450,947. Twine making machine. Harold Flater, Ernst T. Waernhoff, and Nils G. Franson, assignors to International Harvester Co., Chicago, Ill. Filed June 15, 1946. 7 claims. (Cl. 57-32.) A machine impregnates the individual surfaces of a plurality of twisted paper strands and, in the same operation, twists the strands into multiple strand twine.

2,450,957. Roll stripping mechanism. Louis A. Hawthorne, assignor to Johns-Manville Corp., New York, N. Y. Filed Feb. 17, 1945. 9 claims. (Cl. 92-66.) A stripping mechanism is provided for removal of the built-up sheet from an accumulator of a wet machine.

2,450,992. Free-fall aerial container. William J. Sanderson, assignor to the United States of America as represented by the Secretary of Agriculture. Filed Nov. 16, 1945. 6 claims. (Cl. 244-138.) The container is provided with a pair of wings; it can be dropped from airplanes without the use of parachutes.

2,451,087. Method of reconditioning battery plates. Alva L. Hindall, assignor to General Motors Corp., Detroit, Mich. Filed Dec. 1, 1944. 5 claims. (Cl. 136-165.) The expander material for the battery plates contains sulphite waste liquor or other soluble lignin material.

2,451,165. Sealing of closures for gusseted paper bags. Carl H. Hartman, assignor to St. Regis Paper Co., New York, N. Y. Filed April 27, 1946. 1 claim. (Cl. 229-62.) A coating of waxy material covers the strip and stitching of a multiwall gusseted paper bag.

2,451,173. Rubberoid tall oil polymers and process for making the same. Richard Richter and John J. Miskel, assignors to Nopco Chemical Co., Brooklyn, N. Y. Filed Dec. 24, 1943. 14 claims. (Cl. 260-97.5.) Acetylated tall oils can be condensed under the influence of heat and in the presence of acidic esterification catalysts to yield polymeric products having semielastic yielding-and-recovering rubberlike properties.

2,451,209. Hollow-walled carton. William P. Frankenstein, Cincinnati, Ohio. Filed March 15, 1943. 5 claims. (Cl. 229-34.) A hollow-wall carton has an inclined inner wall member whereby articles can be mounted therein while on display.

2,451,212. Thermoplastic coating composition. Leon J. Gold, assignor to Milprint, Inc., Milwaukee, Wis. Filed Nov. 26, 1945. 6 claims. (Cl. 106-287.) The coating composition contains 10–60% Norelac, 0.1–15% paraffin, and 2.5–30% plasticizer (*o*- and *p*-tolueneëthylsulphonamides).

2,451,229. Log barking drum. Lawrence H. Lemke, assignor to D. J. Murray Manufacturing Co., Wausau, Wis. Filed Sept. 4, 1944. 2 claims. (Cl. 189-36.) In a welded barking drum structure, an annular series of parallel channel bars is firmly but resiliently connected to the internal integral lugs of several embracing rings in a manner which effectively prevents disruption and deterioration of the assemblages resulting from vibration.

2,451,233. Combined envelope and letter sheet. Santiago M. Menocal, Habana, Cuba. Filed Jan. 11, 1946. 3 claims. (Cl. 229-92.1.)

2,451,305. Pressure head box for paper machines. William P. Shannon, Port St. Joe, Fla. Filed Sept. 12, 1945. 8 claims. (Cl. 92-44.) A head box for a fourdrinier paper machine is provided with an adjustable lip and slice for regulating the thickness of the flow over the complete width of the screen.

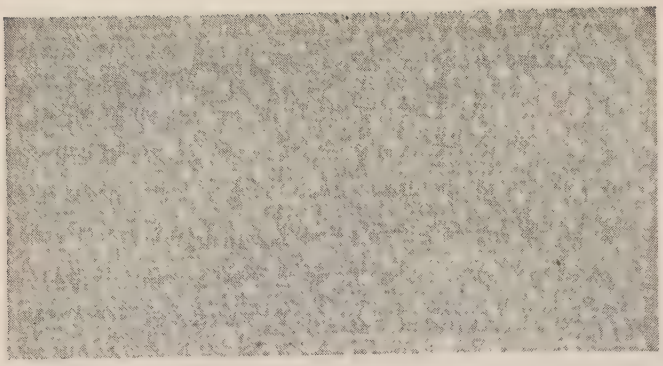
2,451,355. Method of making identification tags. Joseph S. Pecker, assignor to Dennison Manufacturing Co., Framingham, Mass. Filed Sept. 2, 1944. 5 claims. (Cl. 93-91.) The method comprises holding the strand portions along opposite sides of the tag and fusing the two portions together at both of said locations.

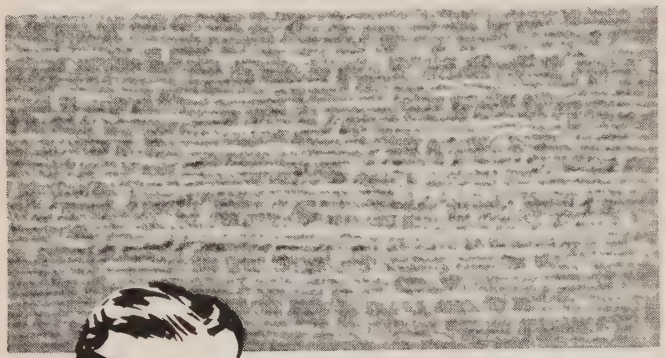
2,451,362. Lining composition and container wall lined therewith. Rudolph M. Snyder, assignor to Henry A. Johnson, Kansas City, Mo. Filed March 28, 1945. 8 claims. (Cl. 106-271.) A formula is given for a barrier lining or coating composition for cartons, barrels, and the like used for shipping asphalt, resins, tars, etc., which have a tendency to adhere to the walls.

2,451,377. Hydrogenation of tall oil. Harding Bliss and William C. Sussky, assignors to Dictaphone Corp., New York, N. Y. Filed May 18, 1945. 7 claims.(Cl. 260-97.5.) Tall oil is hydrogenated in dioxane which enables a sharp separation between the saturated and unsaturated acids.

2,451,410. Thermosetting laminating sirups. Edgar M. Queeny, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed Nov. 19, 1947. 6 claims. (Cl. 260-38.) A laminating agent consists of 1–15 parts of a silica aerogel per 100 parts of a resin from formaldehyde and melamine, urea, thiourea, phenols, and the like.

CLARENCE J. WEST, Chairman, Committee on Bibliography, TAPPI.





Bottom felts, both Orr, are identical except that one is an ORR-CHEM (treated chemically) and the other was untreated. Ran consecutively on same machine under identical conditions and for the same length of time. The ORR-CHEM is still in good condition; the untreated Orr is worn out.

ORR-CHEM REPORT

When the first ORR-CHEM ad appeared (Jan. 2, 1947) only a handful of mills had tried these new longer-wearing, better-draining, treated felts but they liked them and gave them their stamp of approval.

Today, after two years of experience with ORR-CHEM treated felts, hundreds of mills rate them "tops" and have standardized on them.

Today, approximately 40% of all felts woven at Orr are given this special chemical treatment to make them:

a. GO ONTO THE MACHINE EASIER
b. SET TO THE MACHINE BETTER
c. DRAIN FASTER
d. STAY IN SERVICE LONGER

Regardless of the type or speed of your machine, the kinds of stock you are using, or the grades you are running, you should give ORR-CHEM chemically treated felts an opportunity to prove their superiority.

ALSO STANDARD UNTREATED FELTS.

THE ORR FELT & BLANKET CO.
PIQUA, OHIO

ORR-CHEM

2,451,446. Light-weight fiber containing product. Joseph R. Parsons, assignor to United States Gypsum Co., Chicago, Ill. Filed Sept. 6, 1943. 3 claims. (Cl. 106-88.) In the preparation of a light-weight sound-insulating material an emulsion containing 20 grams of thin-boiling starch and 15 grams of a wetting agent is used.

2,451,448. Treatment of pigment comprising calcium carbonate. Harold R. Rafton, assignor to Raffold Process Corp., Andover, Mass. Filed April 11, 1947, 12 claims. (Cl. 23-66.) Calcium carbonate pigment is treated in the appartus covered by U. S. patent 2,448,049 to improve at least one of the properties of adhesive requirement, oil absorption, and gloss-imparting quality of the pigment.

October 19, 1948

2,451,558. Chemically treated wood pulp and a method of producing a cellulosic product. Paul H. Schlosser and Kenneth R. Gray, assignors to Rayonier, Inc., Shelton, Wash. Filed Nov. 6, 1944. 14 claims. (Cl. 106-163.) Improvement of wood pulp for the manufacture of viscose and like products is obtained by the addition of 0.01 to 0.2% of a mixed ether containing a polyalkylene oxide radical and a substituted aryl hydrocarbon radical.

2,451,636. Cutting machine. William R. Spiller, assignor to Harris-Seybold Co., Cleveland, Ohio. Filed June 21, 1946. 5 claims. (Cl. 164-54.) A guillotine-type paper cutter is described with particular reference to means for adjusting and controlling the cutting mechanism.

2,451,644. Container. Geoffrey H. Wood, Toronto, Canada. Filed April 2, 1946. 1 claim. (Cl. 229-39.) The end wall of a container is so constructed that, when it is to be used as a waste receptacle, it can be folded to form a hopper-type cover with a central aperture.

2,451,708. Rotary refiner. Edmund P. Arpin, Jr. Filed Dec. 16, 1944. 7 claims. (Cl. 92-26.) In a rotary refiner including a rotor, a shaft, a pair of heads fixed thereon, rods extending between the heads, and refining elements pivotally mounted from the rods for radially outward swinging movement, the outward movement is limited by a disk freely mounted on the shaft.

2,451,792. Hot-melt coating composition. Arthur E. Young and Kenneth D. Bacon, assignors to The Dow Chemical Co., Midland, Mich. Filed Nov. 9, 1945. 2 claims. (Cl. 260-16.) A formula for a wax-free, hot-melt coating composition suitable for bread wrappers contains ethylcellulose, an ester of polymerized resin with a polyhydric alcohol, and a maleic anhydride-modified ester gum.

2,451,806. Cushioned display container. Percy A. Carson, assignor to General Electric Co., Schenectady, N. Y. Filed Nov. 13, 1945. 6 claims. (Cl. 206-45.14). A packing container for fragile articles, such as incandescent lamps.

October 26, 1948

2,452,054. Fire-retardant composition and process. Grinnell Jones, Walter Juda, and Samuel Soll, assignors to Albi Manufacturing Co., Inc., Boston, Mass. Filed June 20, 1944. 20 claims. (Cl. 260-17.3.) The composition contains 12 parts formaldehyde, 15 parts urea, 67 parts monoammonium phosphate, and 8 parts starch.

2,452,055. Amylaceous fire-retardant composition. Grinnell Jones, Walter Juda, and Samuel Soll, assignors to Albi Manufacturing Co., Inc., Boston, Mass. Filed Aug. 19, 1942. 3 claims. (Cl. 106-15.) A thin-boiling starch (675 grams) in 2835 ml. cold water is heated five minutes at 80–85°, the solution at 40° is treated with 210 grams copper sulphate in 225 ml. ammonium hydroxide and 225 ml. water, and then with 2465 grams of diammonium phosphate in portions of 300–400 grams.

2,452,135. Paper pulp machine. John C. Lowe, assignor to Harmer R. Lutz, Sellersville, Pa. Filed Oct. 26, 1944. 1 claim. (Cl. 92-23.) An apparatus is designed for continuously disintegrating paper stock.

2,452,150. Egg carton. Wesley J. Roberts, North Little Rock, Ark. Filed June 19, 1945. 5 claims. (Cl. 229-15.) A container is claimed which has opening through which the eggs can be candled while packed and which can be used for displaying the eggs for sale.

2,452,226. Laminated product and method of manufacture. Charles N. Cone, assignor to M and M Wood Working Co., Portland, Ore. Filed June 15, 1944. 13 claims. (Cl. 154-132.) A method and apparatus are described for bonding a sheet of paper to the surface of a wood veneer by means of asphalt.

2,452,235. Blackboard. Leon J. Gold, assignor to Milprint, Inc., Milwaukee, Wis. Filed March 2, 1946. 1 claim. (Cl. 35-68.) A coating is proposed for a sheet of black paper to be used as a blackboard.

2,452,399. Stock agitating and circulating attachment for stock tanks used in pulp and paper mills. John Stadler, Montreal, Canada. Filed July 9, 1945. 3 claims. (Cl. 259-109.)

2,452,485. Sealing and carrying device. William Obernauer, assignor to Ernest Jacobson, New York, N. Y. Filed April 17, 1945. 5 claims. (Cl. 229-52.) A method for sealing packages with tape which also provides a carrying means.

2,452,533. Preparation of papermaking fiber and other useful materials from straw. Sidney D. Wells, assignor to The Institute of Paper Chemistry, Appleton, Wis. Filed June 30, 1944. 5 claims. (Cl. 19-5.) Flax straw is treated in a rod mill and subjected to a screening operation.

November 2, 1948

2,452,542. Continuous process for making alkali cellulose. William H. Bradshaw and William R. Schmitz, Jr., assignors to E. I. du Pont de Nemours & Co., Wilmington, Del. Filed Oct. 27, 1942. 4 claims. (Cl. 260-233.)

2,452,631. Self-adjusting wood peeler. Curtice B. Cameron, Laurel, Miss. Filed May 4, 1946. 3 claims. (Cl. 144-208.) A wood peeler includes a longitudinally supported trough through which an endless conveyor is adapted to carry logs while they are engaged by various sets of resiliently tensioned flights of cutting blades to remove the bark.

2,452,755. Compressed laminated machine roll. Paul R. Heygel, assigned to Ecusta Paper Corp., Pisgah Forest, N. C. Filed June 19, 1945. 4 claims. (Cl. 242-68.) A rewinder roll is formed of a light-weight laminated roll with a small metal core.

2,452,952. Carton. Frank D. Palmer, assignor to F. D. Palmer, Inc., Chicago, Ill. Filed July 3, 1944. 3 claims. (Cl. 229-5.5.) An end closure is described which can be easily secured to the body of the container to provide a hermetically sealed, siftproof end.

2,452,959. Machine for themoplastically treating materials. Melvin H. Sidebotham, Newton, Mass. Filed Aug. 23, 1945. 3 claims. (Cl. 101-114.) A paper sheet is treated with a film of powdered thermoplastic material, the web is heated, the material is spread over the web, and the web is then cooled to secure the material to the paper.

2,453,099. Treatment of calcium sulphite. Harold R. Rafton, assignor to Raffold Process Corp., Andover, Mass. Filed Oct. 4, 1943. 14 claims. (Cl. 23-129.) Calcium sulphite is treated in the apparatus described in U. S. patent 2,448,049 (Aug. 31, 1948). The casein requirement is reduced from 45 to 13% and the oil absorption from 50.2 to 31.5%; the gloss of the coated paper is increased from 40 to 50%.

November 9, 1948

2,453,159. Container. Lewis E. Richter, Shumway, Ill. Filed May 10, 1945. 2 claims. (Cl. 229-14.) A waterproof container is described which is suitable for ammunition and the like.

2,453,213. Process of treating lignin residues. Eduard Farber, assignor to Timber Engineering Co., Washington, D. C. Filed May 10, 1945. 15 claims. (Cl. 260-124.) The activity of lignin is increased by heating 100 parts lignin with 20 to 200 parts of alkali at a temperature between 150 and 250°.

2,453,286. Bottle container. Werner Von Clemm, Syosset, N. Y. Filed Dec. 19, 1944. 2 claims. (Cl. 229-17.) A container is described which is designed for packing wine bottles.

2,453,393. Combined spoon and lid for containers. Robert C. Wilson, assignor of one fourth to Richard W. Wilson, Chula Vista, Calif. Filed Sept. 17, 1945. 2 claims. (Cl. 229-1.5.)

2,453,537. Tube-forming machine. Edwin R. Phillips, assignor to Morton Salt Co., Chicago, Ill. Filed April 12, 1946. 9 claims. (Cl. 93-80.) Noncylindrical paper tubes are formed by winding strips of paper on a rotating mandrel.

2,453,574. Controlled ventilated container. Irving Hill, assignor to The Lawrence Paper Co., Lawrence, Kan. Filed May 13, 1946. 8 claims. (Cl. 229-42.) Provision is made for air circulation in an egg container during shipping and storage.

2,453,614. Easy packing container. Jack R. Belsinger, assignor to Belsinger Inc., Atlanta, Ga. Filed May 15, 1946. 2 claims. (Cl. 229-23.) A container is provided for packing rayon yarns.

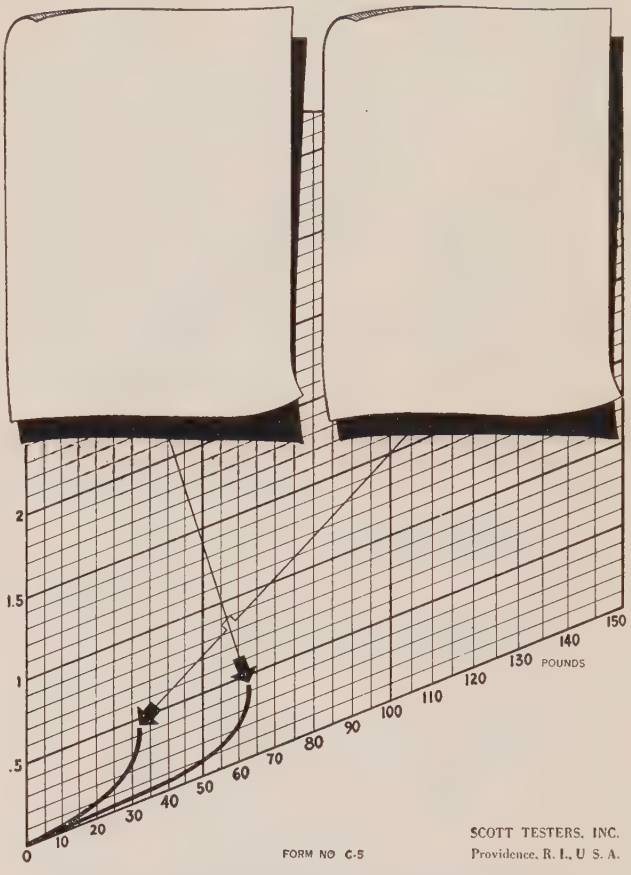
2,453,644. Hot melt coating composition containing polyethylene, terpene resin, chlorinated diphenyl resin, and paraffin. Walter C. Steinkraus, Chicago, Ill. Filed Dec. 6, 1945. 4 claims. (Cl. 260-28.5.) A hot-melt coating contains polyethylene, a thermoplastic terpene resin, chlorinated diphenyl resin, and paraffin or microcrystalline wax.

November 16, 1948

2,453,758. Art of manufacturing aquatic decoys. Arthur H. Risch, assignor to Pulp Reproduction Co., Milwaukee, Wis. Filed April 20, 1945. 2 claims. (Cl. 43-3.) A molded pulp aquatic decoy.

TESTED IS TRUSTED

They look alike — but



a Scott Paper Tester "picturizes" the difference

Because *Scott Testers give you detailed knowledge of the tensile, deflection and stretch characteristics of your paper, these machines are an invaluable aid in formulation and in quality control. The results are shown in picturized permanent graphs which are convenient for filing and reference.

Request Catalog 48 showing various models with capacities from 4 grams to 1 ton; including equipment for Finch Tear Test, both edge and wet.

REQUEST CATALOG 48

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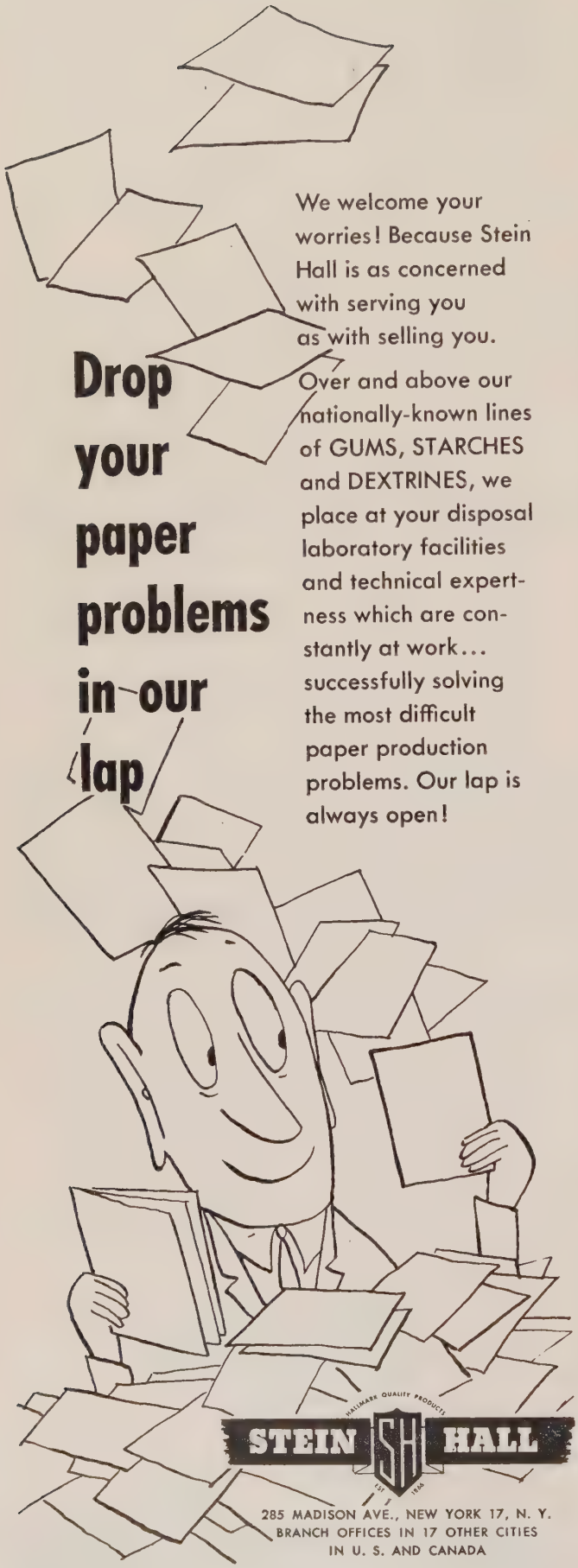
Standard of the World


We welcome your worries! Because Stein Hall is as concerned with serving you as with selling you.
Drop your paper problems in our lap
Over and above our nationally-known lines of GUMS, STARCHES and DEXTRINES, we place at your disposal laboratory facilities and technical expertness which are constantly at work... successfully solving the most difficult paper production problems. Our lap is always open!
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2,453,775. Method of concentrating waste sulphite liquor with recovery of sulphur dioxide. Laurence R. Beath and Harold S. Hill, assignors to Price Brothers & Co., Ltd., Quebec, Canada. Filed April 17, 1945. 12 claims. (Cl. 23-178.) The heat required for the concentration is supplied to the waste liquor by passing an electric current through it.

2,453,789. Twinemaking machine. Harold Flater, Ernst T. Waernhoff, and Nils G. Franson. Filed Dec. 9, 1947. 12 claims. (Cl. 57-31.) A spinning disk.

2,453,829. Shipping carton. Smith A. Blackman, assignor to Gaylord Container Corp., St. Louis, Mo. Filed Sept. 26, 1946. 1 claim. (Cl. 229-23.) The invention consists in providing auxiliary top and/or bottom end closures for heavy duty shipping cartons.

2,453,836. Machine for forming containers from flexible material. Paul C. Elliott, assignor to Luther K. Funkhouser, Dayton, Ohio. Filed Nov. 7, 1941. 27 claims. (Cl. 93-391.) The patent covers a machine for forming paper containers for milk or other liquids.

2,453,880. Container. Byron M. Vanderbilt and Paul T. Parker, assignors to Standard Oil Development Co., Linden, N. J. Filed Dec. 28, 1943. 2 claims. (Cl. 220-64.) A container which permits ready removal of tacky, rubbery organic materials has an internal coating consisting of a water-soluble metal soap, a water-insoluble wax, zinc stearate, and a copolymer of butadiene and acrylonitrile.

2,453,889. Method for heat sealing the seams of paper bags. Albert M. Bojanower, assignor to Western Waxed Paper Co., Oakland, Calif. Filed March 7, 1944. 2 claims. (Cl. 154-116.) The paper is heated along the seam by means of a small jet of steam.

2,453,908. Bottle carrier. John Harhay, assignor to Los Angeles Paper Box Factory, Los Angeles, Calif. Filed April 27, 1946. 4 claims. (Cl. 229-52.) In a bottle carrier the ends are triangular in shape for improved strength and economy of material.

2,453,947. Hydraulic type log debarker having plural log-rotating chucks independently revolvable about a common axis. Frank H. Swift, assignor to Crown Zellerbach Corp., San Francisco, Calif. Filed Dec. 22, 1945. 5 claims. (Cl. 144-208.) The patent relates to a hydraulic barking machine for short logs which will handle logs of a wide range of diameters.

2,454,013. Shopping bag with foldable, extensible top. Frank F. Scherzinger, Henderson, Nev. Filed March 14, 1945. 1 claim. (Cl. 150-1.7.)

2,454,029. Carton Albert E. Bentham, assignor to The Baltimore Paper Box Co., Baltimore, Md. Filed July 21, 1945. 1 claim. (Cl. 229-23.) A fiberboard egg case.

2,454,196. Millinery box. Ersel C. Mulnix, Lake Bluff, Ill. Filed Nov. 8, 1946. 3 claims. (Cl. 229-31.) A cardboard box is designed for millinery or the like.

November 23, 1948

2,454,352. Package for rolls and the like. Le Roy W. Staunton and Ralph L. Atkinson, assignors to United Wallpaper, Inc., Chicago, Ill. Filed March 29, 1946. 6 claims. (Cl. 206-47.)

2,454,532. Process for defibering lignocellulose while subjected to steam and a digestive chemical. Henry E. Walter, assignor to Wood Conversion Co., Cloquet, Minn. Filed Aug. 3, 1940. 9 claims. (Cl. 92-6.) The Asplund process is carried out in the presence of 1–10% sodium carbonate, 1% sodium hydroxide, 10% borax, and other alkalies. The properties of the fibers depend not only upon the pH but also, in part, upon the type of chemical used. The effect of sodium aluminate is highly specific.

2,454,533. Manufacture of fibrous products deriving from lignocellulose. Henry E. Walter, assignor to Wood Conversion Co., Cloquet, Minn. Filed Aug. 3, 1940. 22 claims. (Cl. 92-6.) The defibration of aspen and pine by the Asplund process is carried out in the presence of sodium sulphite or a mixture of borax and sodium bisulphite. The sodium sulphite treatment is stated to shorten the time for hydration and reduces the breakage of the fibers during hydration.

2,454,534. Process for defibering lignocellulose while subjected to steam and alkali-metal hydroxide. Henry E. Walter, assignor to Wood Conversion Co., Cloquet, Minn. Filed Aug. 3, 1940. 9 claims. (Cl. 92-6.) The Asplund process is carried out in the presence of 5% sodium hydroxide. This treatment shortens the time of hydration, reduces the breakage of the fiber during hydration, and improves the formation and the properties of the paper.

2,454,573. Folding box. Joseph Scher, New York, N. Y. Filed Aug 3, 1945. 1 claim. (Cl. 229-34.) A box is designed for shipping foods, particularly frozen foods.

November 30, 1948

2,454,906. Paper cup and handle therefor. Walter E. Amberg, assignor to Lily-Tulip Cup Corp., New York. N. Y. Filed Nov. 19, 1945. 5 claims. (Cl. 229-52.) The method of attaching a handle to a paper cup is described.

2,455,016. Lath board. George A. Buttress, Los Angeles, Calif. Filed April 11, 1944. 3 claims. (Cl. 72-124.) A lath board consists of a plaster layer between a fibrous front cover sheet and a back cover sheet having plaster-receiving apertures extending therethrough.

2,455,055. Curing frame for resin impregnated stock sheets. Harry C. Gray, assignor to Continental Can Co., New York, N. Y. Filed Sept. 7, 1944. 3 claims. (Cl. 154-1.) A frame for curing resin-impregnated laminated sheets is described.

2,455,063. Method of forming metal closures for paper containers. George F. Jackson, assignor to Continental Can Co., N. Y. Filed Sept. 7, 1944. 3 claims. (Cl. 154-1.) A frame for for curing resin-impregnated laminated sheets is described.

2,455,109. Method of fabricating merchandise holders and display devices. Frederick H. Bowers, Kalamazoo, Mich. Filed June 28, 1945. 1 claim. (Cl. 93-3.)

2,455,124. Collapsible container. Henry A. Johnson, Kansas City, Mo. Filed Oct. 15, 1945. 2 claims. (Cl. 229-37.) A container for asphalt, resin, ice cream, etc., has a bottom construction or closure which effectively prevents leakage of the liquid or semiliquid contents.

2,455,291. Cellular carton. Leon Benoit, assignor to Robert Gair Co., Inc., New York, N. Y. Filed July 4, 1945. 4 claims. (Cl. 229-28.) A carton suitable for eggs, fruits, candies, etc.

2,455,304. Method for sealing cartons. Reynolds Guyer, assignor to Waldorf Paper Products Co., St. Paul, Minn. Filed Nov. 9, 1944. 16 claims. (Cl. 93-36.8.) A method for the manufacture of a shiftproof and liquid tight folding carton is described.

2,455,295. Cellular carton. John W. Cox, assignor to Shellmar Products Corp., Chicago, Ill. Filed Oct. 23, 1942. 5 claims. (Cl. 229-29.) This covers a molded pulp egg carton.

December 7, 1948

2,455,454. Method of making a fire resistant laminated fabric. Zachary T. Walter, Los Angeles, Calif. Filed Aug. 4, 1944. 4 claims. (Cl. 154-140.) Fibrous material is saturated with a chlorinated paraffin and then coated with cellulose acetate in a solvent for the chlorinated paraffin; the sheets superimposed while wet.

2,455,622. Beating engine and the like. Andrew G. Stewart, Edinburgh, Scotland. Filed June 4, 1945. 4 claims. (Cl. 92-22.) A V-shaped construction is built over the beater which facilitates the washing of the beater.

2,455,685. Dispensing container. Chester M. Lehman, St. Louis, Mo. Filed Oct. 1, 1945. 3 claims. (Cl. 229-11.) The container has a yieldable bottom and is designed for matches, toothpicks, and like articles.

2,455,737. Method of attaching metal closures to containers. John Coyle, assignor to Continental Can Co., Inc., New York, N. Y. Filed July 29, 1944. 1 claim. (Cl. 113-120.) A method is described of seaming a metal end to a container body having flat sides and rounded corners.

2,455,777. Floor covering. James R. Jones, assignor to Paulsboro Manufacturing Co., Paulsboro, N. J. Filed Nov. 29, 1944. 5 claims. (Cl. 41-22.) A paper sheet (0.005–0.007 inch thick) is saturated and printed, laminated to a felt base or other foundation layer, and covered with a wear layer.

2,455,836. Box blank separator. Marinus Van Brummelen, New York, N. Y. Filed July 11, 1947. 6 claims. (Cl. 271-1.) This relates to a device for consecutively separating individual box blanks from a plurality of such blanks stacked on a rack.

December 14, 1948

2,455,923. Bituminous laminated material. William F. Fair, Jr., assignor to Koppers Co., Inc., Pittsburgh, Pa. Filed Feb. 4, 1944. 3 claims. (Cl. 154-2.) A laminated sheet material, consisting of a plurality of paper sheets bonded by means of asphalt or coal-tar pitch, is improved by covering the outer surfaces and edges with a coating of coal-digestion pitch.

2,456,047. Container. Herbert L. Carpenter, assignor to Carpenter Container Corp., Brooklyn, N. Y. Filed June 19, 1945. 1 claim. (Cl. 229-5.7.) This is a continuation of U. S. patent 2,382,858 and relates to a container with a reinforced cover.

2,456,059. Machine for and method of banding boxes. William F. Grupe, assignor to Beech-Nut Packing Co., Canajoharie, N. Y. Filed March 6, 1946. 6 claims. (Cl. 216-20.) A method is described for banding cartons for shipping purposes.

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2,456,168. Display carton with sliding closure. Albert Behrens, New York, N. Y. Filed Oct. 11, 1946. 8 claims. (Cl. 206-44.) A display container has an opening capable of being opened and closed somewhat in the manner of a roll top desk.

2,456,249. Apparatus for producing variegated fiber lengths in the manufacture of paper. George L. Bidwell, assignor to Riegel Paper Corp., New York, N. Y. Filed April 21, 1944. 2 claims. (Cl. 92-20.) An improved apparatus is described for creating the desired variegated fiber length, for insuring hydration of the fibers, and for positively controlling the variegated fiber length.

2,456,365. Barking drum. Burl Branch, Brantford, Ontario, Canada. Filed July 27, 1945. 4 claims. (Cl. 144-208.)

2,456,483. Container. Robert Beattie, assignor to Tide Water Associated Oil Co., Bayonne, N. J. Filed March 13, 1945. 3 claims. (Cl. 229-14.) A method is described for forming a container for lubricating oils and the like.

2,456,495. Coating machine. Harry W. Faeber, assignor to Time, Inc., New York, N. Y. Filed Aug. 1, 1945. 6 claims. (Cl. 91-50.) A plurality of layers of coating material is applied successively and in relatively close adjacent stations to the web as it passes through the machine. The machine also dries the coated web.

December 21, 1948

2,456,610. Package assembly. James A. Baker, assignor to Milprint, Inc., Milwaukee, Wis. Filed July 2, 1945. 4 claims. (Cl. 206-45.33.) The patent covers an improved package assembly for tapered cup-shaped containers.

2,456,735. Container. Walter A. Roselle, New York, N. Y. Filed Nov. 19, 1945. 3 claims. (Cl. 229-7.) A paper container has a body with a triangular spout at one corner.

2,456,841. Container. Fred L. Rushing, assignor to Gaylord Container Corp., St. Louis, Mo. Filed June 22, 1945. 1 claim. (Cl. 229-45.) A shipping carton for fruits and vegetables has a body with a slip cover and hand holes.

2,456,883. Jordan apparatus. William Messinger and Dwight E. Jones, assignors to E. D. Jones & Sons Co., Pittsfield, Mass. Filed Sept. 27, 1945. 3 claims. (Cl. 92-27.) Various modifications of the jordan are described.

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2,456, 985. Apparatus for the manufacture of abrasive webs. Nicholas E. Oglesby, assignor to Behr-Manning Corp., Troy, N. Y. Filed Aug. 25, 1943. 20 claims. (Cl. 91-18.) This is a division of U. S. patent 2,403,018 (July 2, 1946). Steam under pressure is used as the atomizing agent and the product is applied in a semienclosed space substantially filled with an atmosphere of steam. Glue is the most commonly used adhesive.

2,457,025. Fungusproofing composition. Paul G. Benignus, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed Aug. 11, 1944. 11 claims. (Cl. 260-22.) The composition contains copper 8-hydroxyquinoline, a modified alkyd resin, and a mixture of chlorinated diphenyls.

2,457,107. Dispensing container. Stanley Verner, Montreal, Quebec, Canada, Filed Feb. 24, 1945. 2 claims. (Cl. 229-27.) A one-piece container for dispensing gummed tape.

December 28, 1948

2,457,108. Adhesive and method of making. Chester L. Baker and Robert H. Sams, assignors to Philadelphia Quartz Co., Philadelphia, Pa. Filed July 24, 1943. 16 claims. (Cl. 106-79.) A dry-mix adhesive is formed of 65 parts of soya flour (50–53% protein), 2 parts steam-distilled pine oil, and 33 parts of sodium silicate (11% Na_2O, 31.9% SiO_2, and 57% H_2O). Other formulas are given.

2,457,198. Container and blank therefor. John G. Bell, assignor to Morbell Product Corp., Chicago, Ill. Filed Oct. 22, 1945. 8 claims. (Cl. 229-4.5.) A double-wall container is claimed which is suitable for packing ice cream in bulk.

2,457,216. Means and method for producing infusion bags with nontangling handles. Lewis B. Eaton and Robert W. Vergobbi, assignors to Pneumatic Scale Corp., Ltd., Quincy, Mass. Filed Dec. 11, 1945. 27 claims. (Cl. 93-3.) The necessary apparatus is described.

2,457,237. Apparatus for producing filled bags. Stanley R. Howard, assignor to Pneumatic Scale Corp., Ltd., Quincy, Mass. Filed June 4, 1947. 11 claims. (Cl. 93-2.) The patent relates to an apparatus for attaching a handle comprising a tag and a length of twine to an infusion bag.

2,457,256. Apparatus for manufacture of coated webs. Romie L. Melton, Raymond C. Benner, and Henry P. Kirchner, assignors to The Carborundum Co., Niagara Falls, N. Y. Filed Dec. 29, 1939. 15 claims. (Cl. 91-18.) This is a continuation of U. S. patent 2,187,624 (Jan. 16, 1940) and relates to the manufacture of granular coated webs of paper and the like.

2,457,291. Carton and display stand. Frederick W. Wenzel, assignor to Hummel & Downing Co., Milwaukee, Wis. Filed Feb. 10, 1945. 5 claims. (Cl. 229-27.) Means are provided for interlocking the several parts of a carton to provide a partition therein during the course of erection.

2,457,307. Bottle carrier. Maynard G. Hall and Thomas Hurban, Jr., assignors to Empire Box Corp., Garfield, N. J. Filed July 12, 1945. 15 claims. (Cl. 224-45.2.) The construction of a bottle carrier with a finger-receiving opening is described.

2,457,308. Bottle carrier. Maynard G. Hall and Thomas Hurban, Jr., assignors to Empire Box Corp., Garfield, N. J. Filed Nov. 9, 1945. 4 claims. (Cl. 224-45.)

2,457,357. Novel adhesive product and process of making same. James E. Fenn, Baldwin, N. Y. Filed June 14, 1947. 9 claims. (Cl. 260-17.5.) Concentrated sulphite waste liquor is treated with 0.5 to 3% of phosphoric acid.

2,457,433. Apparatus for coating paper. William Barrett, assignor to Minnesota and Ontario Paper Co., Minneapolis, Minn. Filed Nov. 24, 1943. 6 claims. (Cl. 91-55.) A method for the roll coating of paper at speeds up to 1200 feet per minute is described.

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NATIONAL

Paper Coating Conference, Pantlind Hotel, Grand Rapids, Mich., April 26–27, 1949.

General Fall Meeting, Multnomah Hotel, Portland, Ore., September 11–15, 1949.

Fourth Engineering Conference of the Pulp and Paper Industry, Statler Hotel, Boston, Mass., October 31, November 1–3, 1949.

LOCAL SECTIONS

CHICAGO SECTION: Chicago Bar Association, Chicago, Ill.
April 18, 1949.

DELAWARE VALLEY SECTION: Engineers Club, Philadelphia.
April 28, 1949—Testing Methods—A Panel Discussion, R. J. Knoll, Scott Paper Co., Moderator.
May 26, 1949—"Long Range View of the Pulp Supply," by James L. Ritchie, U. S. Pulp Producers Association.

EMPIRE STATE SECTION: The Sagamore, Bolton Landing, Lake George, N. Y.
June 2–4, 1949—Annual meeting.

Western New York Group: Prospect House, Niagara Falls, N. Y.
May 11, 1949—Douglas Converse, Canadian Industries Ltd.

Metropolitan Group: Fraunces Tavern, New York, N. Y.
May 9, 1949, June 11, 1949.

Hudson Valley Group: Village Inn, So. Glens Falls, N. Y.
April 21, 1949. Allen Lowe, Speaker.

NEW ENGLAND SECTION: Hotel Weldon, Greenfield, Mass.
May 13, 1949.

OHIO SECTION: Manchester Hotel, Middletown, Ohio
April 21, 1949—Annual Meeting.

MAINE-NEW HAMPSHIRE SECTION:
June 17–18, 1949, Spring meeting at the Wentworth-by-the Sea, Portsmouth, N. H.

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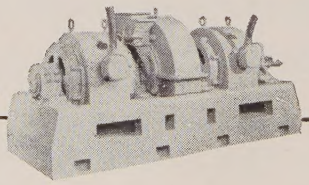

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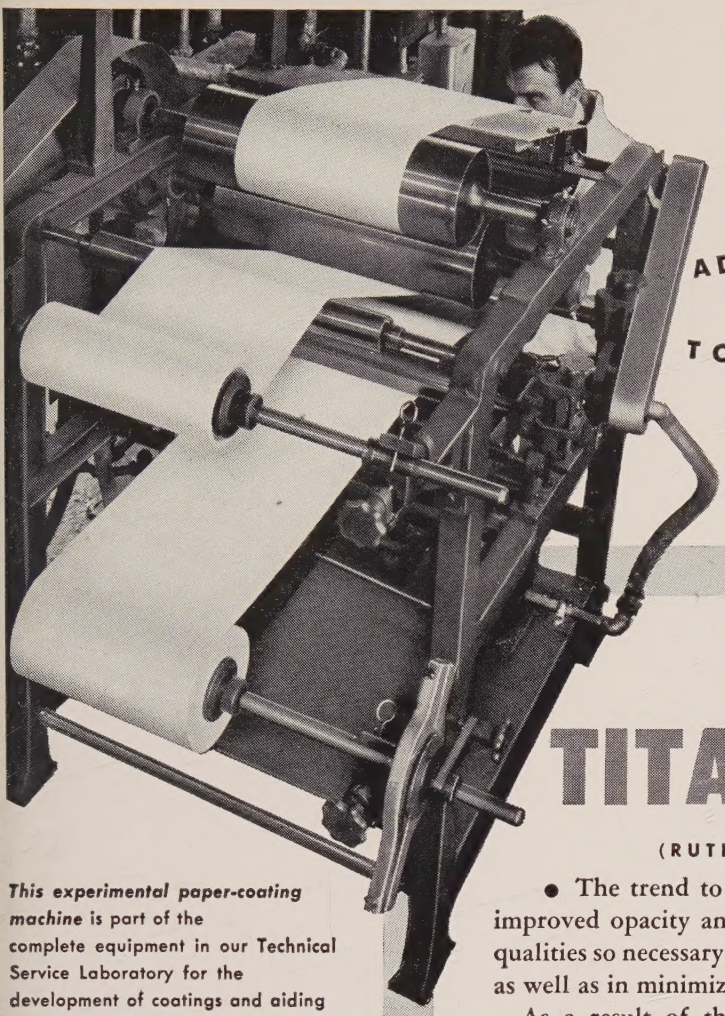

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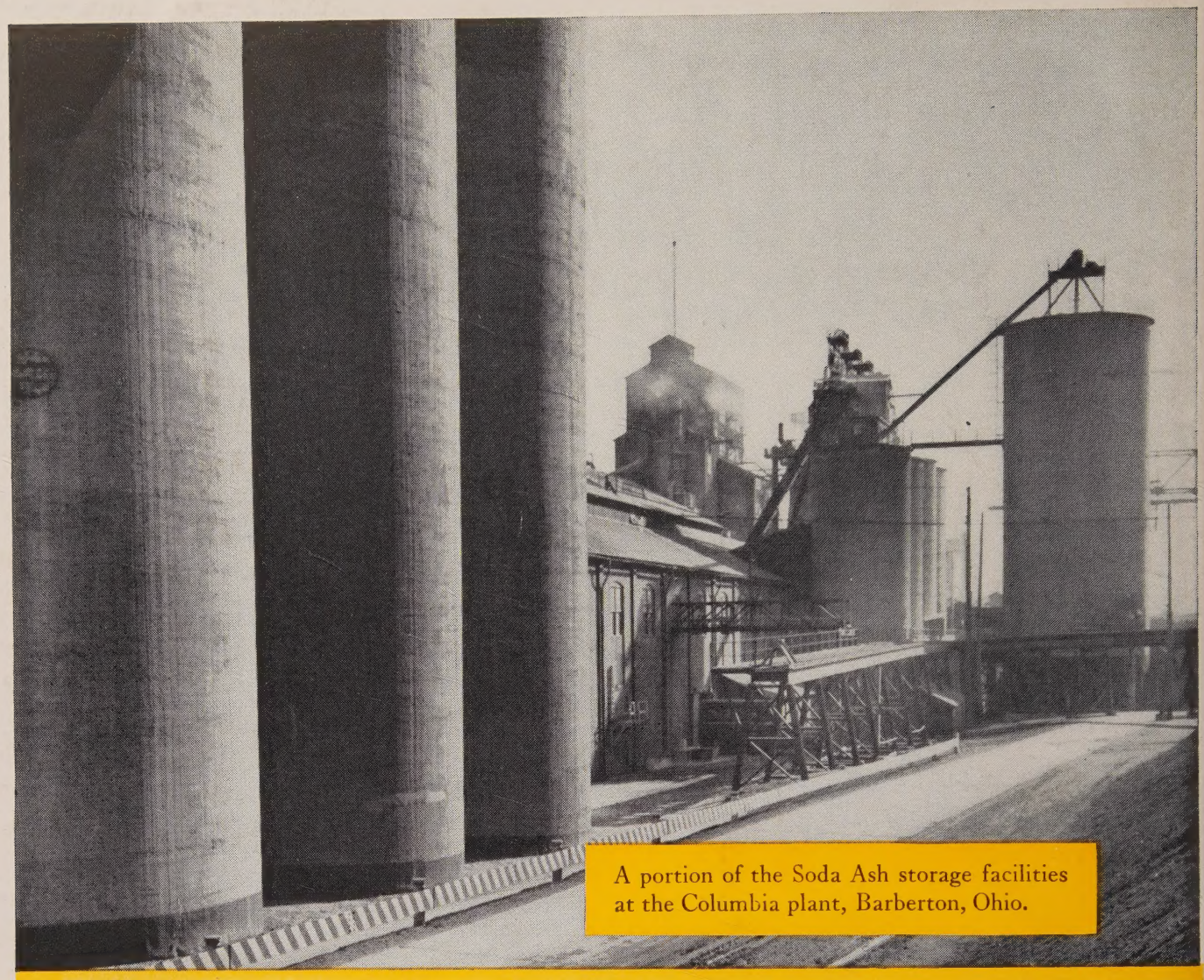

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